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Magnetic Measurement and Control Catalog

LakeShore

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Model 475 DSP Gaussmeter

- Full-scale ranges from 35 mG to 350 kG
- DC measurement resolution to 0.02 mG
- Basic DC accuracy of ±0.05%
- DC to 50 kHz frequency range (probe-dependent)
- 15 band-pass and 3 low-pass AC filters
- Peak capture to 20 µs pulse widths
- Data buffer sampling rates to 1000 readings per s
- Computer interface sampling rates to 100 new readings per s
- Integrated electromagnet field control algorithm
- Standard probe included
- Standard and custom probes available

The First Gaussmeter with DSP Technology

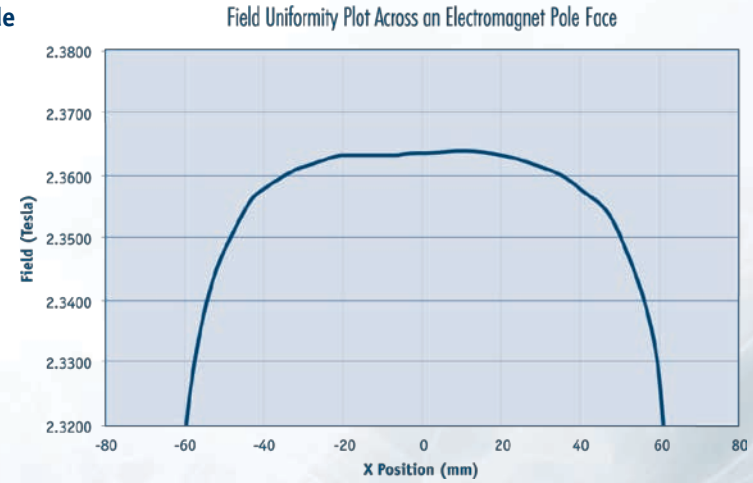
The First DSP Gaussmeter…

Lake Shore combined the technical advantages of digital signal processing with over a decade of experience in precision magnetic field measurements to produce the first commercial digital signal processor (DSP) based Hall effect gaussmeter, the Model 475. DSP technology creates a solid foundation for accurate, stable, and repeatable field measurement while simultaneously enabling the gaussmeter to offer an unequaled set of useful measurement features. The Model 475 is intended for the most demanding DC and AC applications. In many cases it provides the functionality of two or more instruments in a field measurement system.

The power of DSP technology is demonstrated in the superior performance of the Model 475 in DC, RMS, and Peak measurement modes.

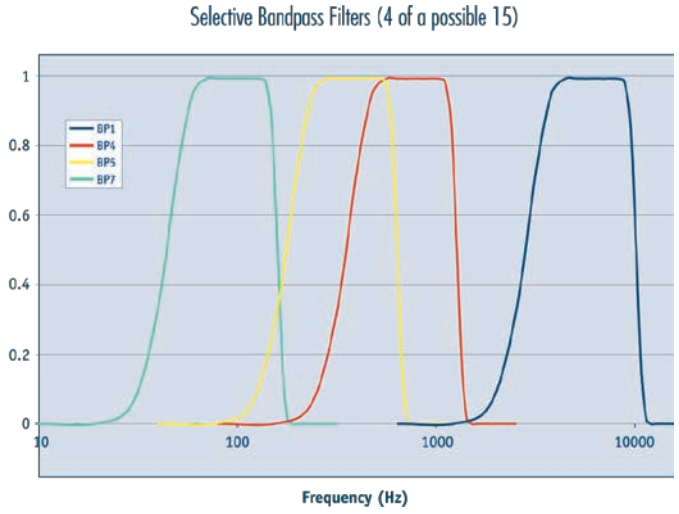
DC Measurement Mode

Static or slowly changing fields are measured in DC mode, where the accuracy, resolution, and stability of the Model 475 are most evident. In this mode, the gaussmeter takes advantage of the internal auto zero function and probe linearity compensation to provide its best accuracy. Measurement resolution is enhanced by advanced signal processing capability, allowing users the choice of high reading rates to 100 readings per second or high resolution to 5¾ digits. The Model 475 also features front-end amplification specifically designed to complement DSP data acquisition, providing high stability and repeatability. That, along with probe temperature compensation, makes the Model 475 the most stable gaussmeter ever produced by Lake Shore, suiting it perfectly for demanding DC measurement applications such as field mapping and field control.



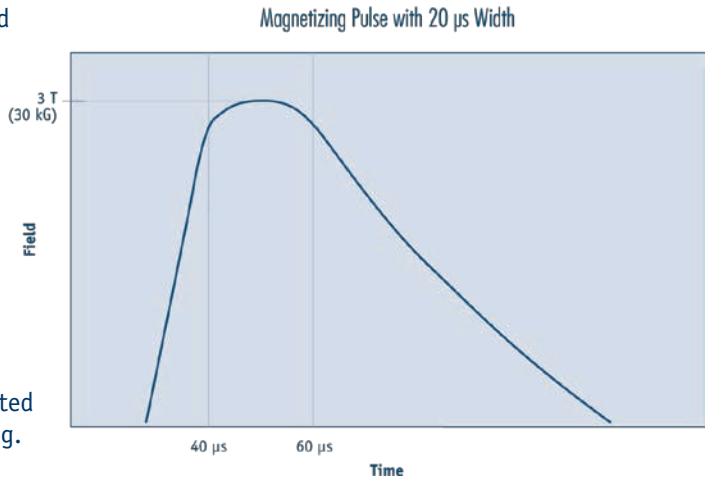
RMS Measurement Mode

Periodic, AC fields are measured in RMS mode, which highlights the uniquely flexible filter functions of the Model 475. An overall RMS frequency range of 0.5 Hz to 50 kHz is offered by the gaussmeter. Selectable band-pass and low-pass filters allow users to reject unwanted signals and improve measurement performance. The exclusive Lake Shore DSP algorithms also free the Model 475 from the limitations of conventional RMS conversion hardware and provide better dynamic range, resolution, and frequency response than ever before. These improvements permit meaningful RMS field measurements with broad frequency content or in noisy environments.



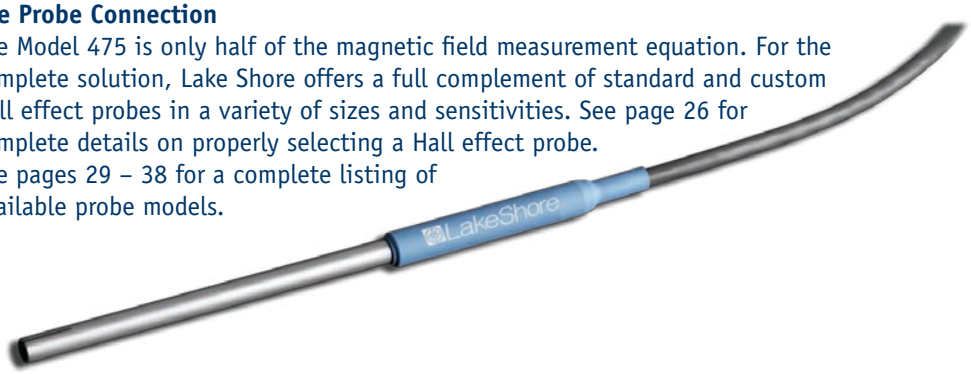
Peak Measurement Mode

Pulsed fields are measured in Peak mode, which is a natural extension of the high-speed data acquisition necessary for DSP operation. Fast instrument sample rates permit capture of positive and negative field pulses as narrow as 20 µs in width, which can be held for an unlimited length of time with no sag. This is ideal for most magnetizers and other fast pulse applications. For more moderate field changes, the Model 475 can process the captured data to create other features. The gaussmeter can be configured to follow the peak of a periodic waveform for evaluation of crest factor. The Model 475 can also be used to sample field changes at 1000 readings per second that can later be read over the interface to illustrate the shape of pulses or other waveforms.



The Probe Connection

The Model 475 is only half of the magnetic field measurement equation. For the complete solution, Lake Shore offers a full complement of standard and custom Hall effect probes in a variety of sizes and sensitivities. See page 26 for complete details on properly selecting a Hall effect probe.
See pages 29 – 38 for a complete listing of available probe models.



Advanced Features

The Model 475 combines hardware and firmware elements to create advanced features that facilitate automation and materials analysis.

Field Control

A built-in PI control algorithm turns the Model 475 into an essential building block for magnetic field control in electromagnet systems. It, along with a voltage-programmable magnet power supply, is all that is needed to control stable magnetic fields in an electromagnet at the user-specified setpoint. One of the built-in analog voltage outputs drives the program input of the power supply for either bipolar or unipolar operation. See page 60 for more information.

High Speed Data Transfer

The IEEE-488 interface can be set to send readings in binary format rather than the more common ASCII format. This reduces interface overhead, enabling real-time reading rates up to 100 new readings per second. Temperature compensation is not available at the highest interface rate.

Data Buffer

Internal memory provides storage for 1024 field readings in a data buffer. The buffer can be filled at high speed, up to 1000 readings per second, which is as much as ten times faster than the computer interface. Stored readings can then be retrieved over interface at slower speed and processed offline. A trigger input can be used to initiate the data log sequence. Slower sample rates can be programmed if desired.

Trigger In and Trigger Out

A TTL-level hardware trigger into the instrument can be used to initiate the data log sequence. A TTL-level hardware trigger out indicates when the instrument completes a reading, and can be used to synchronize other instruments in the system. An IEEE-488 software-based trigger can be used like the hardware trigger in.

Measurement Features

The Model 475 offers a variety of features to enhance the usability and convenience of the gaussmeter.

Autorange: In addition to manual range selection, the instrument automatically chooses an appropriate range for the measured field. Autorange works in DC and AC measurement modes.

Auto Probe Zero: Allows the user to zero all ranges for the selected measurement mode with the push of a key.

Display Units: Field magnitude can be displayed in units of G, T, Oe, and A/m.

Max/Min Hold: The instrument stores the fully processed maximum and minimum DC or RMS field value. This differs from the faster peak capture feature that operates on broadband, unprocessed field reading information.

Relative Reading: Relative feature calculates the difference between a live reading and the relative setpoint to highlight deviation from a known field point. This feature can be used in DC, RMS, or Peak measurement mode.

Instrument Calibration: Lake Shore recommends an annual recalibration schedule for all precision gaussmeters. Recalibrations are always available from Lake Shore, but the Model 475 allows users to field calibrate the instrument if necessary. Recalibration requires a computer interface and precision low resistance standards of known value.

Instrument Probe Features

The Model 475 has several capabilities that allow the best possible measurements with Lake Shore probes. These firmware-based features work in tandem with the probe's calibration and programming to ensure accurate, repeatable measurements and ease of setup. Many of the features require probe characteristics that are stored in the probe connector's non-volatile memory.

Probe Field Compensation: The Hall effect devices used in gaussmeter probes produce a near linear response in the presence of magnetic field. The small non-linearities present in each individual device can be measured and subtracted from the field reading. Model 475 probes are calibrated in this way to provide the most accurate DC readings.

Probe Temperature Compensation: Hall effect devices show a slight change in sensitivity and offset with temperature. Probe sensitivity temperature effects can be measured and subtracted out of field readings. A temperature sensor in the probe tip relays real time temperature to the gaussmeter, enabling compensation. Although temperature effects contribute only a small fraction of the overall probe measurement accuracy, temperature compensation will often improve measurement and control stability.

Probe Temperature Display: The gaussmeter can display the probe's temperature in °C along with a field reading when using a probe that includes a temperature sensor.

Frequency Display: When operating in RMS mode, the gaussmeter can display the frequency of the measured AC field along with a field reading (up to 20 kHz).

Probe Information: The gaussmeter reads the probe information on power up or any time the probe is changed to allow hot swapping of probes. Critical probe information can be viewed on the front panel and read over the computer interface to ensure proper system configuration.

Extension Cables: The complex nature of Hall effect measurements make it necessary to match extension cables to the probe when longer cables are needed. Keeping probes and their extensions from getting mixed up can become a problem when more than one probe is in use. The Model 475 alleviates most of the hassle by allowing users to match probes to extensions in the field. Stored information can be viewed on the front panel and read over the computer interface to ensure proper mating.

Hall Effect Generators (Magnetic Field Sensors): The Model 475 will operate with a discrete Hall effect generator when a suitable probe is not available. Users can program nominal sensitivity and serial number into an optional MCBL-6 blank connector to provide all gaussmeter functions except field and temperature compensation. If no sensitivity information is available, the Model 475 reverts to resistance measurement.

Display and Interface Features

Display
The Model 475 has a 2-line by 20-character vacuum fluorescent display. During normal operation, the display is used to report field readings and give results of other features such as max/min or relative. The display can also be configured to show probe temperature or frequency. When setting instrument parameters, the display gives the operator meaningful prompts and feedback to simplify operation. The operator can also control display brightness.

Following are four examples of the various display configurations:

***Normal Reading**—the display configured to show the RMS field value and frequency, and the probe temperature*

***Max DC Hold On**—the display configured to show both the Maximum and Minimum DC field values*

***Max Peak Hold On**—the display configured to both show the positive and negative Peak readings*

***Field Control On**—the display configured to show the field control setpoint and current field value, when field control is active*

Keypad
The instrument has a 22-position keypad with individual keys assigned to frequently used features. Menus are reserved for less frequently used setup operations. The keypad can be locked out to prevent unintended changes of instrument setup.

Alarm and Relay
High and low alarms are included in the instrument. Alarm actuators include display annunciator, audible beeper, and two relays. The relays can also be controlled manually for other system needs.

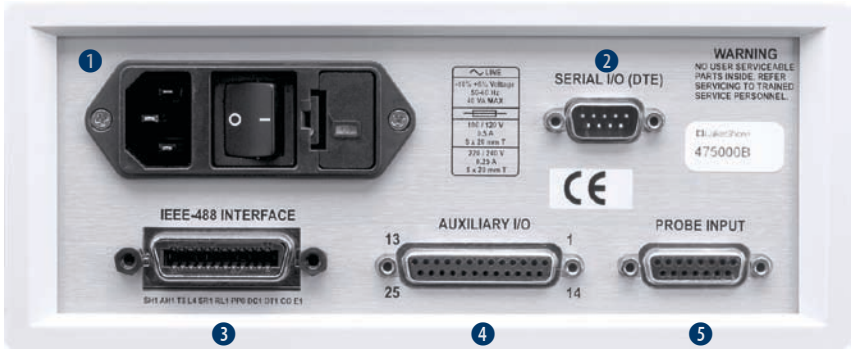
Voltage Output 1
The first voltage output gives access to amplified voltage signal directly from the probe. This voltage is corrected for the nominal sensitivity of the probe and provides the widest bandwidth of the three voltage outputs. In wide band AC mode, the signal can be viewed on an oscilloscope to observe the shape of AC fields. In Peak mode, the output can be used to view a pulse shape or other characteristic of a momentary signal. Output 1 serves only as a diagnostic tool in DC and narrow band AC modes because modulation of the probe signal prevents a clear view of the field response.

Voltage Output 2
The second voltage output provides a voltage proportional to measured field with the benefits of some signal processing. The output is produced by the DSP through a fast D/A converter. The output signal is updated at 40 kHz, giving good response for low to mid frequency fields. Signal quality degrades at high frequency because of the sampling rate. This voltage can be corrected for probe offset and for the nominal sensitivity of the probe.

Voltage Output 3
The third voltage output provides a voltage proportional to measured field with the most signal processing of the three outputs. All probe compensation available to the display readings, including temperature compensation, can be performed on this output. The output is produced by the microprocessor through a high-resolution, 16-bit, D/A converter updated at 30 readings per second. This output can also be used for field control.

Computer Interface
Two computer interfaces are included with the Model 475, serial RS-232C and parallel IEEE-488. Both allow setup of all instrument parameters and read-back of measured values. The reading rate over the interface is nominally 30 readings per second but settings from 10 to 100 readings per second are available. LabVIEW™ drivers are provided to instrument users — consult Lake Shore for availability.

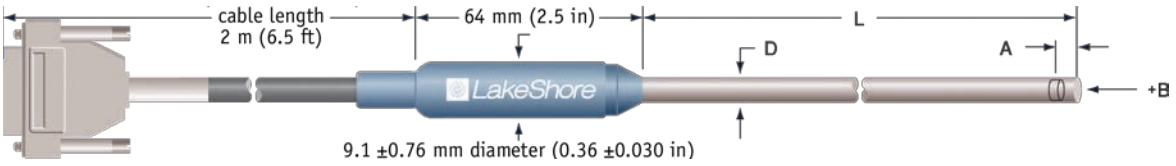
1. Line input assembly
2. Serial I/O (DTE)
3. IEEE-488 interface
4. Auxiliary I/O
5. Probe input



Gaussmeter Hall Probes

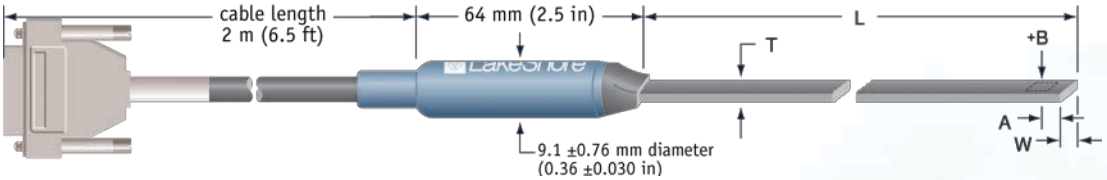
The Model 475 includes one of the Lake Shore probes listed below—specify probe model number when ordering. See page 26 for details on properly selecting a probe and for a complete listing of available probe models.

Axial Probes



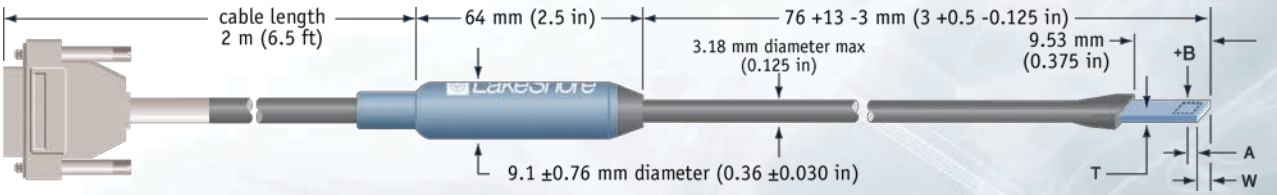
	L (in)	D (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg)	Operating temp range (°C)	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
HMNA-1904-VR	4 ±0.125	0.187 dia ±0.005	0.005 ±0.003	0.030 dia (approx)	Fiberglass epoxy	DC to 20 kHz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG and ±0.25% 30 to 35 kG	0 °C to +75 °C	±0.09 G/°C	±0.04%/°C	Yes
HMMA-2502-VR	2 ±0.063	0.25 dia ±0.006	0.015 ±0.005		Aluminum	DC to 10 kHz						
HMNA-1904-VF	4 ±0.125	0.187 dia ±0.005	0.005 ±0.003		Fiberglass epoxy	DC to 800 Hz	**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.10% to 30 kG and ±0.15% 30 to 35 kG		±0.13 G/°C	–0.005%/°C	
HMMA-2502-VF	2 ±0.063	0.25 dia ±0.006	0.015 ±0.005		Aluminum	DC to 400 Hz						

Transverse Probes



	L (in)	T (in)	W (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
HMMT-6J04-VR	4 ±0.125	0.061 max	0.180 ±0.005	0.150 ±0.050	0.040 dia (approx)	Aluminum	DC to 800 Hz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG; ±0.25% 30 to 35 kG	0 °C to +75 °C	±0.09 G/°C	±0.04%/°C	Yes
HMNT-4E04-VR	4 ±0.125	0.045 max	0.150 ±0.005			Fiberglass epoxy	DC to 20 kHz						
HMMT-6J04-VF	4 ±0.125	0.061 max	0.180 ±0.005			Aluminum	DC to 400 Hz	**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.10% to 30 kG; ±0.15% 30 to 35 kG		±0.13 G/°C	–0.005%/°C	
HMNT-4E04-VF	4 ±0.125	0.045 max	0.150 ±0.005			Fiberglass epoxy	DC to 800 Hz						

Flexible Transverse Probes



	W (in)	T (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
HMFT-3E03-VR	0.135 max	0.025 max	0.125 ±0.005	0.040 dia (approx)	Flexible plastic tubing	DC to 20 kHz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG; ±0.25% 30 to 35 kG	0 °C to +75 °C	±0.09 G/°C	±0.015%/°C	Yes
HMFT-3E03-VF						DC to 800 Hz	**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.10% to 30 kG; ±0.15% 30 to 35 kG		±0.13 G/°C	–0.005%/°C	

Model 475 Specifications

General Measurement

(Does not include probe error, unless otherwise specified)
Input type: Single Hall effect sensor
Probe features: Linearity Compensation, Temperature Compensation, Auto Probe Zero, and Hot Swap
Measurement features: Autorange, Max/Min Hold, Relative Mode, and Frequency
Connector: 15-pin D style

DC Measurement

Probe Type Ranges	5¾-digit Resolution	4¾-digit Resolution	3¾-digit Resolution
HST Probe			
350 kG	000.001 kG	000.01 kG	000.1 kG
35 kG	00.0001 kG	00.001 kG	00.01 kG
3.5 kG	0.00001 kG	0.0001 kG	0.001 kG
350 G	000.003 G	000.02 G	000.1 G
35 G	00.0020 G	00.015 G	00.04 G
HSE Probe			
35 kG	00.0001 kG	00.001 kG	00.01 kG
3.5 kG	0.00001 kG	0.0001 kG	0.001 kG
350 G	000.001 G	000.01 G	000.1 G
35 G	00.0003 G	00.002 G	00.01 G
3.5 G	0.00020 G	0.0015 G	0.004 G
UHS Probe			
35 G	00.0001 G	00.001 G	00.01 G
3.5 G	0.00001 G	0.0001 G	0.001 G
350 mG	000.003 mG	000.02 mG	000.1 mG
35 mG	00.0020 mG	00.015 mG	00.04 mG

Measurement resolution (RMS noise floor)**:** Indicated by value in above table for shorted input
Display resolution: Indicated by number of digits in above table

	5¾-digit Resolution	4¾-digit Resolution	3¾-digit Resolution
3 dB bandwidth:	1 Hz	10 Hz	100 Hz
Time constant:	1 s	0.1 s	0.01 s
Maximum reading rate:	10 rdg/s	30 rdg/s	100 to 1000 rdg/s*

**Limited feature set, interface dependent*

DC accuracy: ±0.05% of rdg ±0.005% of range
DC temperature coefficient: ±0.01% of rdg ±0.003% of range/°C

AC RMS Measurement

Probe Type Ranges	4¾-digit Resolution
HST Probe	
350 kG	000.01 kG
35 kG	00.001 kG
3.5 kG	0.0002 kG
350 G	000.02 G
35 G	00.020 G
HSE Probe	
35 kG	00.001 kG
3.5 kG	0.0001 kG
350 G	000.02 G
35 G	00.002 G
3.5 G	0.0020 G
UHS Probe	
35 G	00.001 G
3.5 G	0.0002 G
350 mG	000.02 mG
35 mG	00.020 mG

Measurement resolution (RMS noise floor)**:** Indicated by value in above table for shorted input
Display resolution: Indicated by number of digits in above table
Max reading rate: 30 rdg/s (100 to 1000 rdg/s; limited feature set, interface dependent)
AC accuracy: ±1% of reading ≥ 1% of full-scale range
AC frequency range: 1 Hz to 1 kHz, narrow band mode; 100 Hz to 20 kHz, wide band mode
AC band limiting (filters): 18 user-selected frequencies of 3 low-pass or 15 band-pass

Peak Measurement

Probe Type Ranges	4¾-digit Resolution
HST Probe	
350 kG	000.01 kG
35 kG	00.001 kG
3.5 kG	0.0002 kG
350 G	000.02 G
35 G	00.020 G
HSE Probe	
35 kG	00.001 kG
3.5 kG	0.0001 kG
350 G	000.02 G
35 G	00.002 G
3.5 G	0.0020 G
UHS Probe	
35 G	00.001 G
3.5 G	0.0002 G
350 mG	000.02 mG
35 mG	00.020 mG

Measurement resolution (RMS noise floor): Indicated by value in above table for periodic mode and shorted input
Display resolution: Indicated by number of digits in above table
Max reading rate (periodic mode): 30 rdg/s (100 to 1000 rdg/s; limited feature set, interface dependent)
Peak accuracy (5 Hz to 20 kHz): ±2% of rdg ≥ 1% of full-scale range (20 μs or longer pulse width)
Peak accuracy (20 kHz to 50 kHz): ±5% of rdg ≥ 1% of full-scale range (20 μs or longer pulse width)
Peak frequency range (periodic mode): 50 Hz to 5 kHz
Peak frequency range (pulse mode): 5 Hz to 50 kHz

Temperature Measurement

Temperature range: Probe dependent (typically 0 °C to 75 °C)
Measurement resolution: 0.01 °C
Temperature display resolution: 0.01 °C
Electronic accuracy: ±0.7 °C

Front Panel

Display type: 2-line × 20-character, vacuum fluorescent with 9 mm high characters
Display resolution: To ±5¾ digits
Display update rate: 5 rdg/s
Display units: gauss (G), tesla (T), oersted (Oe), and ampere per meter (A/m)
Units multipliers: μ, m, k, M
Display annunciators:
DC – DC measurement mode
RMS – AC RMS measurement mode
PK – Peak measurement mode
MX – Max hold value
MN – Min hold value
SP – Relative setpoint value
CSP – Field control setpoint value
LED annunciators:
Relative reading mode
Alarm active
Remote IEEE-488 operation
Keypad: 22 full-travel keys
Front panel features: Display prompts, front panel lockout, and brightness control

Interfaces

RS-232C
Baud: 9600, 19200, 38400, and 57600
Update rate: 30 rdg/s (ASCII)
Software support: LabVIEW™ driver
Connector: 9-pin D-style, DTE configuration

IEEE-488.2
Capabilities: SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT1, C0, and E1
Update rate: 30 rdg/s (ASCII), to 100 rdg/s (binary, no temperature compensation)
Software support: LabVIEW™ driver

Data Buffer
Capacity: 1024 field readings
Reading rate: 1 to 1000 rdg/s
Data transfer: Through computer interface after data is logged
Trigger: Hardware trigger to begin data log sequence

Alarm
Settings: High/low setpoint, Inside/outside, Audible, and Sort
Actuators: LED annunciator, beeper, and relays

Relays
Number: 2
Contacts: Normally open (NO), normally closed (NC), and common (C)
Contact rating: 30 VDC at 2 A
Operation: Follows alarm or operated manually
Connector: In 25-pin I/O connector

Voltage output 1
Configuration: Real-time analog voltage output of wide-band AC signal
Range: ±3.5 V
Scale: ±3.5 V = ±full scale on selected range
Frequency response: 1 Hz to 40 kHz (wide-band AC)
Accuracy: Probe-dependent
Noise: ±1.0 mV
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: In 25-pin I/O connector

Voltage Output 2
Configuration: Voltage output of field value, generated by DAC
Range: ±5 V
Scale: ±3.5 V = ±full scale on selected range
Resolution: 16-bit, 0.15 mV
Update rate: 40,000 updates/s
Accuracy: ±10 mV
Noise: ±0.3 mV
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: In 25-pin I/O connector

Voltage Output 3
Configuration: Voltage output of compensated DC or RMS field value, generated by DAC (also used for field control)
Range: ±10 V
Scale: User-specified (defaults same as Voltage Output 2)
Resolution: 16-bit, 0.3 mV
Update rate: 30 updates/s
Accuracy: ±2.5 mV
Noise: ±0.3 mV
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: In 25-pin I/O connector

General

Ambient temperature: 15 °C to 35 °C at rated accuracy, 5 °C to 40 °C with reduced accuracy
Power requirement: 100, 120, 220, and 240 VAC (+6%, -10%), 50 Hz or 60 Hz, 20 VA
Size: 216 mm W × 89 mm H × 318 mm D (8.5 in × 3.5 in × 12.5 in), half rack
Weight: 3 kg (6.6 lb)
Approval: CE mark

Probes and Extensions
Probe compatibility: Full line of standard and custom probes available (not compatible with Model 450/421 probes)—see page 7 for included (additional standard probes available)
Hall sensor compatibility: Front panel programmable sensitivity and serial number for user-supplied Hall sensor—see page 40
Extension cable compatibility: Calibrated or uncalibrated probe extension cables with an EEPROM are available from 10 ft to 100 ft—see page 39

Lake Shore calibrated extension cables maintain the same accuracy as the Model 475 probe.

The uncalibrated version requires the operator to load the matching probe data file into the cable PROM directly from the Model 475 front panel. Additional errors caused by the uncalibrated extension cables are ±0.02% of field reading error and 1 °C temperature reading error.

Ordering Information

Part number	Description
475	Model 475 DSP gaussmeter
475-HMXX-XXXX-XX	Model 475 DSP gaussmeter with standard probe choice *—specify selected probe number for HMXX-XXXX-XX (see list on page 7)*
Specify line power option	
VAC-100	100 VAC configured, includes U.S. power cord
VAC-120	120 VAC configured, includes U.S. power cord
VAC-220	220 VAC configured, includes universal Europe power cord
VAC-240	240 VAC configured, includes universal Europe power cord
VAC-120-ALL	120 VAC configured, includes U.S. and universal Europe power cords and all fuses
Accessories included	
106-253	I/O mating connector
106-264	I/O mating connector shell
4060	Zero gauss chamber
MAN-475	Model 475 user manual
Accessories available	
4005	1 m (3.3 ft) long IEEE-488 (GPIB) computer interface cable assembly—includes extender required for simultaneous use of IEEE cable and auxiliary I/O connector
4065	Large zero gauss chamber for gamma probe
HMCBL-6	User programmable cable with EEPROM (1.8 m [6 ft])
HMCBL-20	User programmable cable with EEPROM (6.1 m [20 ft])
HMPEC-10	Probe extension cable with EEPROM (3 m [10 ft]), calibrated
HMPEC-10-U	Probe extension cable with EEPROM (3 m [10 ft]), uncalibrated
HMPEC-25	Probe extension cable with EEPROM (7.6 m [25 ft]), calibrated
HMPEC-25-U	Probe extension cable with EEPROM (7.6 m [25 ft]), uncalibrated
HMPEC-50	Probe extension cable with EEPROM (15 m [50 ft]), calibrated
HMPEC-50-U	Probe extension cable with EEPROM (15 m [50 ft]), uncalibrated
HMPEC-100	Probe extension cable with EEPROM (30 m [100 ft]), calibrated
HMPEC-100-U	Probe extension cable with EEPROM (30 m [100 ft]), uncalibrated
RM-½	Rack mount kit for one ½-rack gaussmeter in 483 mm (19 in) rack
RM-2	Rack mount kit for two ½-rack gaussmeters in 483 mm (19 in) rack
Calibration services	
CAL-N7-DATA	New instrument calibration for Model 455/475 with certificate and data
CAL-475-CERT	Instrument recalibration with certificate
CAL-475-DATA	Instrument recalibration with certificate and data

All specifications are subject to change without notice
Custom probes available — consult Lake Shore

Model 455 DSP Gaussmeter

- Field ranges from 35 mG to 350 kG
- DC measurement resolution to 0.02 mG
- Basic DC accuracy of ±0.075%
- DC to 20 kHz AC frequency range
- AC narrow and wide band modes
- Standard probe included
- Standard and custom probes available

Introduction

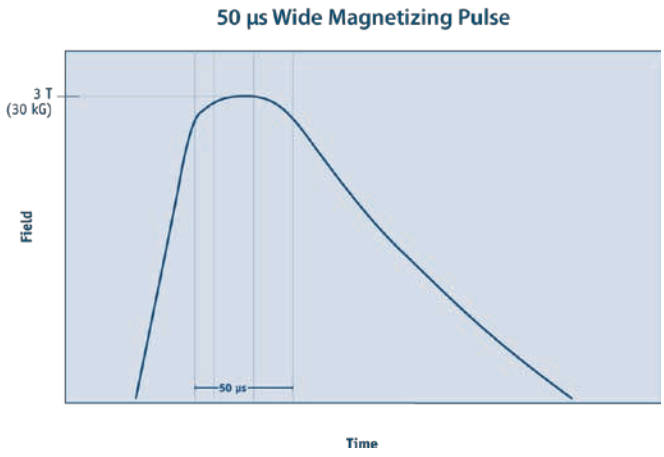
The Model 455 digital signal processing (DSP) gaussmeter combines the technical advantages of DSP technology with many advanced features at a moderate price. DSP technology creates a solid foundation for accurate, stable, and repeatable field measurements. Advanced features including DC to 20 kHz AC frequency range, peak field detection to 50 µs pulse widths, DC accuracy of 0.075%, and up to 5¾ digits of display resolution make the Model 455 ideal for both industrial and research applications. For added functionality and value, the Model 455 includes a standard Lake Shore Hall probe.

DC Measurement Mode

Static or slowly changing fields are measured in DC mode. In this mode, the Model 455 takes advantage of the internal auto zero function and probe linearity compensation to provide a basic DC accuracy of ±0.075%. Measurement resolution is enhanced by advanced signal processing capability, allowing users the choice of reading rates to 30 readings per second or high resolution to 5¾ digits. Front-end amplification specifically designed to complement DSP data acquisition provides high stability and repeatability. That, along with probe temperature compensation, provides superior stability ideally suited for demanding DC measurement applications such as field mapping.

RMS Peak Mode

Periodic AC fields are measured in RMS mode. The Model 455 provides an overall RMS frequency range of 10 Hz to 20 kHz and is equipped with both narrow and wide band frequency modes. While in narrow band mode, frequencies above 1 kHz are filtered out for improved measurement performance. The exclusive DSP algorithms free the Model 455 from the limitations of conventional RMS conversion hardware and provide for an excellent dynamic range, resolution, and frequency response.



Peak Measurement Mode

Pulsed fields are measured in Peak mode, which is a natural extension of the high-speed data acquisition necessary for DSP operation. Fast instrument sample rates permit capture of positive and negative transient fields as narrow as 50 µs pulse widths. The peak reading can be held for an unlimited length of time with no sag. This is ideal for most magnetizers and other fast pulse applications. The Model 455 can also be configured to follow the peak of a periodic waveform for evaluation of crest factor.

The Probe Connection

The Model 455 is only half of the magnetic measurement equation. For the complete solution, Lake Shore offers a full complement of standard and custom Hall effect probes in a variety of sizes and sensitivities. One of ten common standard Hall probes is included with the Model 455. See page 13 for details on the ten Hall probes you can choose to get with the Model 455.

Measurement Features

The Model 455 offers a variety of features to enhance the usability and convenience of the gaussmeter.

Autorange: In addition to manual range selection, the instrument automatically chooses an appropriate range for the measured field. Autorange works in DC and AC measurement modes.

Auto Probe Zero: Allows the user to zero all ranges for the selected measurement mode with the push of a key.

Display Units: Field magnitude can be displayed in units of G, T, Oe, and A/m.

Max/Min Hold: The instrument stores the fully processed maximum and minimum DC or RMS field value. This differs from the faster peak capture feature that operates on broadband, unprocessed field reading information.

Relative Reading: Relative feature calculates the difference between a live reading and the relative setpoint to highlight deviation from a known field point. This feature can be used in DC, RMS, or Peak measurement mode.

Instrument Calibration: Lake Shore recommends an annual recalibration schedule for all precision gaussmeters. Recalibrations are always available from Lake Shore, but the Model 455 allows users to field calibrate the instrument if necessary. Recalibration requires a computer interface and precision low resistance standards of known value.

Instrument Probe Features

The Model 455 has the best measurement performance when used along with Lake Shore Hall probes. Firmware-based features work in tandem with the probe's calibration and programming to ensure accurate, repeatable measurements and ease of setup. Many of the features require probe characteristics that are stored in the probe connector's non-volatile memory.

Probe Field Compensation: The Hall effect devices used in gaussmeter probes produce a near linear response in the presence of magnetic field. The small nonlinearities present in each individual device can be measured and subtracted from the field reading. Model 455 probes are calibrated in this way to provide the most accurate DC readings.

Probe Temperature Compensation: Hall effect devices show a slight change in sensitivity and offset with temperature. Probe temperature effects can be measured and subtracted out of field readings. A temperature sensor in the probe tip relays real time temperature to the gaussmeter, enabling compensation. Although temperature effects contribute only a small fraction of the overall probe measurement accuracy, temperature compensation will often improve measurement and control stability.

Probe Temperature Display: The gaussmeter can display the probe's temperature in °C along with a field reading when using a probe that includes a temperature sensor.

Frequency Display: When operating in RMS mode, the gaussmeter can display the frequency of the measured AC field along with a field reading.

Probe Information: The gaussmeter reads the probe information on power up or any time the probe is changed to allow hot swapping of probes. Critical probe information can be viewed on the front panel and read over the computer interface to ensure proper system configuration.

Extension Cables: The complex nature of Hall effect measurements make it necessary to match extension cables to the probe when longer cables are needed. Keeping probes and their extensions from getting mixed up can become a problem when more than one probe is in use. The Model 455 alleviates most of the hassle by allowing users to match probes to extensions in the field. Stored information can be viewed on the front panel and read over the computer interface to ensure proper mating.

Hall Effect Generators (Magnetic Field Sensors): The Model 455 will operate with a discrete Hall effect generator when a suitable probe is not available. Users can program nominal sensitivity and serial number into an optional MCBL-6 blank connector to provide all gaussmeter functions except field and temperature compensation. If no sensitivity information is available, the Model 455 reverts to resistance measurement.

Display and Interface Features

Display
The Model 455 has a 2-line by 20-character vacuum fluorescent display. During normal operation, the display is used to report field readings and give results of other features such as max/min or relative. The display can also be configured to show probe temperature or frequency. When setting instrument parameters, the display gives the operator meaningful prompts and feedback to simplify operation. The operator can also control display brightness.

Following are three examples of the various display configurations:

The display configured to show the RMS field value and frequency and the probe temperature

The display configured to show both the maximum and minimum DC field values

The display configured to simultaneously show the positive and negative Peak readings

Keypad
The instrument has a 22-position keypad with individual keys assigned to frequently used features. Menus are reserved for less frequently used setup operations. The keypad can be locked out to prevent unintended changes of instrument setup.

Alarms and Relays
High and low alarms are included in the instrument. Alarm actuators include display annunciator, audible beeper, and two relays. The relays can also be controlled manually for other system needs.

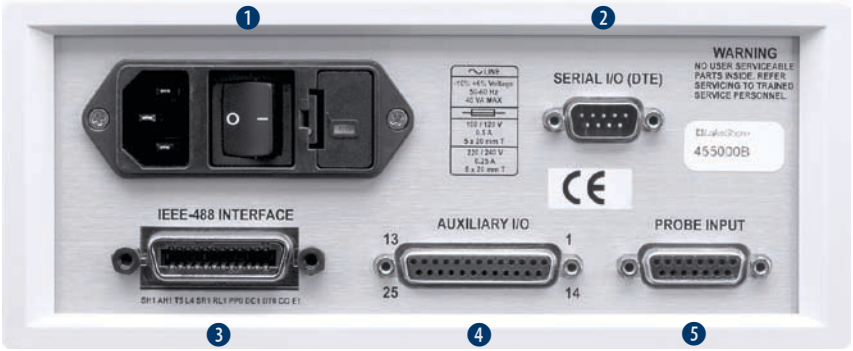
Voltage Output 1
The first voltage output gives access to amplified voltage signal directly from the probe. This voltage is corrected for the nominal sensitivity of the probe and provides the widest bandwidth of the three voltage outputs. In wide band AC mode, the signal can be viewed on an oscilloscope to observe the shape of AC fields. In peak mode, the output can be used to view a pulse shape or other characteristic of a momentary signal. Output 1 serves only as a diagnostic tool in DC and narrow band AC modes because modulation of the probe signal prevents a clear view of the field response.

Voltage Output 2
The second voltage output provides a voltage proportional to measured field with the benefits of some signal processing. The output is produced by the DSP through a fast D/A converter. The output signal is updated at 40 kHz, giving good response for low- to mid-frequency fields. Signal quality degrades at high frequency because of the sampling rate. This voltage can be corrected for probe offset and for the nominal sensitivity of the probe.

Voltage Output 3
The third output provides a voltage proportional to measured field with the most signal processing of the three outputs. All probe compensation available to the display readings, including temperature compensation, can be performed on this output. The output is produced by the microprocessor through a 16-bit D/A converter updated at 30 readings per second.

Computer Interface
Two computer interfaces are included with the Model 455: serial (RS-232C) and parallel (IEEE-488). Both allow setup of all instrument parameters and read-back of measured values. The reading rate over the interface is nominally 30 readings per second. LabVIEW™ drivers are provided to instrument users—consult Lake Shore for availability.

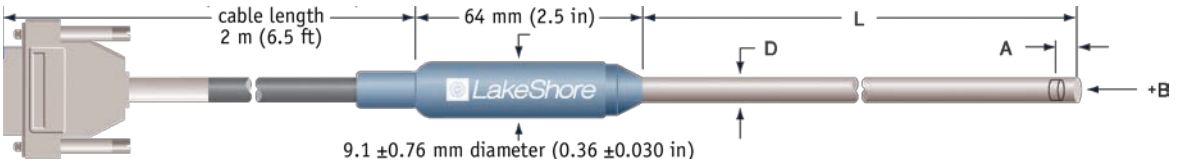
1. Line input assembly
2. Serial I/O (DTE)
3. IEEE-488 interface
4. Auxiliary I/O
5. Probe input



Gaussmeter Hall Probes

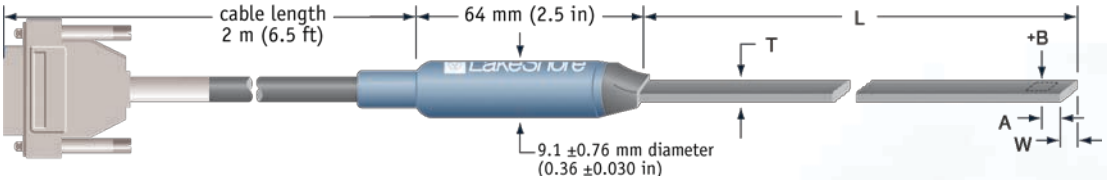
The Model 455 includes one of the Lake Shore probes listed below — specify probe model number when ordering. See page 26 for details on properly selecting a probe and for a complete listing of available probe models.

Axial Probes



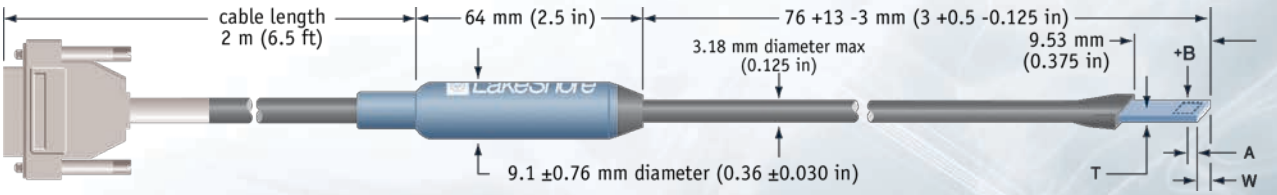
	L (in)	D (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg)	Operating temp range (°C)	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
HMNA-1904-VR	4 ±0.125	0.187 dia ±0.005	0.005 ±0.003	0.030 dia (approx)	Fiberglass epoxy	DC to 20 kHz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG and ±0.25% 30 to 35 kG	0 °C to +75 °C	±0.09 G/°C	±0.04%/°C	Yes
HMMA-2502-VR	2 ±0.063	0.25 dia ±0.006	0.015 ±0.005		Aluminum	DC to 10 kHz						
HMNA-1904-VF	4 ±0.125	0.187 dia ±0.005	0.005 ±0.003		Fiberglass epoxy	DC to 800 Hz	**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.10% to 30 kG and ±0.15% 30 to 35 kG		±0.13 G/°C	–0.005%/°C	
HMMA-2502-VF	2 ±0.063	0.25 dia ±0.006	0.015 ±0.005		Aluminum	DC to 400 Hz						

Transverse Probes



	L (in)	T (in)	W (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
HMMT-6J04-VR	4 ±0.125	0.061 max	0.180 ±0.005	0.150 ±0.050	0.040 dia (approx)	Aluminum	DC to 800 Hz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG; ±0.25% 30 to 35 kG	0 °C to +75 °C	±0.09 G/°C	±0.04%/°C	Yes
HMNT-4E04-VR	4 ±0.125	0.045 max	0.150 ±0.005			Fiberglass epoxy	DC to 20 kHz						
HMMT-6J04-VF	4 ±0.125	0.061 max	0.180 ±0.005			Aluminum	DC to 400 Hz	**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.10% to 30 kG; ±0.15% 30 to 35 kG		±0.13 G/°C	–0.005%/°C	
HMNT-4E04-VF	4 ±0.125	0.045 max	0.150 ±0.005			Fiberglass epoxy	DC to 800 Hz						

Flexible Transverse Probes



	W (in)	T (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
HMFT-3E03-VR	0.135 max	0.025 max	0.125 ±0.005	0.040 dia (approx)	Flexible plastic tubing	DC to 20 kHz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG; ±0.25% 30 to 35 kG	0 °C to +75 °C	±0.09 G/°C	±0.015%/°C	Yes
HMFT-3E03-VF						DC to 800 Hz	**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.10% to 30 kG; ±0.15% 30 to 35 kG		±0.13 G/°C	–0.005%/°C	

Model 455 Specifications

General Measurement

(Does not include probe error, unless otherwise specified)
Input type: Single Hall effect sensor
Probe features: Linearity compensation, temperature compensation, auto probe zero, and hot swap
Measurement features: Autorange, max/min hold, relative mode, and frequency
Connector: 15-pin D style

DC Measurement

Probe type ranges	5¾-digit resolution	4¾-digit resolution	3¾-digit resolution
HST Probe			
350 kG	000.001 kG	000.01 kG	000.1 kG
35 kG	00.0001 kG	00.001 kG	00.01 kG
3.5 kG	0.00001 kG	0.0001 kG	0.001 kG
350 G	000.003 G	000.02 G	000.1 G
35 G	00.0020 G	00.015 G	00.04 G
HSE Probe			
35 kG	00.0001 kG	00.001 kG	00.01 kG
3.5 kG	0.00001 kG	0.0001 kG	0.001 kG
350 G	000.001 G	000.01 G	000.1 G
35 G	00.0003 G	00.002 G	00.01 G
3.5 G	0.00020 G	0.0015 G	0.004 G
UHS Probe			
35 G	00.0001 G	00.001 G	00.01 G
3.5 G	0.00001 G	0.0001 G	0.001 G
350 mG	000.003 mG	000.02 mG	000.1 mG
35 mG	00.0020 mG	00.015 mG	00.04 mG

Measurement resolution (RMS noise floor): Indicated by value in above table for shorted input
Display resolution: Indicated by number of digits in above table

	5¾-digit resolution	4¾-digit resolution	3¾-digit resolution
3 dB bandwidth	1 Hz	10 Hz	100 Hz
Time constant	1 s	0.1 s	0.01 s
Max reading rate	10 rdg/s	30 rdg/s	30 rdg/s

DC accuracy: ±0.075% of reading ±0.005% of range
DC temperature coefficient: ±0.01% of reading ±0.003% of range per °C

AC RMS Measurement

Probe type ranges	4¾-digit resolution
HST Probe	
350 kG	000.01 kG
35 kG	00.001 kG
3.5 kG	0.0002 kG
350 G	000.02 G
35 G	00.020 G
HSE Probe	
35 kG	00.001 kG
3.5 kG	0.0001 kG
350 G	000.02 G
35 G	00.002 G
3.5 G	0.0020 G
UHS Probe	
35 G	00.001 G
3.5 G	0.0002 G
350 mG	000.02 mG
35 mG	00.020 mG

Measurement resolution (RMS noise floor): Indicated by value in above table for shorted input
Display resolution: Indicated by number of digits in above table
Max reading rate: 30 rdg/s
AC accuracy: ±1% of reading ≥1% of full scale range, 10 Hz to 20 kHz
AC frequency range: 10 Hz to 1 kHz, narrow band mode; 135 Hz to 20 kHz, wide band mode

Peak Measurement

Probe type ranges	4¾-digit resolution
HST probe	
350 kG	000.01 kG
35 kG	00.001 kG
3.5 kG	0.0002 kG
350 G	000.02 G
35 G	00.020 G
HSE probe	
35 kG	00.001 kG
3.5 kG	0.0001 kG
350 G	000.02 G
35 G	00.002 G
3.5 G	0.0020 G
UHS probe	
35 G	00.001 G
3.5 G	0.0002 G
350 mG	000.02 mG
35 mG	00.020 mG

Measurement resolution (RMS noise floor): Indicated by value in above table for periodic mode and shorted input
Display resolution: Indicated by number of digits in above table
Max reading rate (periodic mode): 30 rdg/s
Peak accuracy (5 Hz to 20 kHz): ±2% of reading ≥1% of full scale range (50 μs or longer pulse width)
Peak frequency range (periodic mode): 10 Hz to 5 kHz
Peak frequency range (pulse mode): 5 Hz to 20 kHz

Temperature Measurement

Temperature range: Probe dependent (typically 0 °C to 75 °C)
Measurement resolution: 0.01 °C
Temperature display resolution: 0.01 °C
Electronic accuracy: ±0.7 °C

Front Panel

Display type: 2-line × 20-character, vacuum fluorescent with 9 mm high characters
Display resolution: To ±5¾ digits
Display update rate: 5 rdg/s
Display units: gauss (G), tesla (T), oersted (Oe), and ampere per meter (A/m)
Units multipliers: μ, m, k, M
Display annunciators:
DC—DC measurement mode
RMS—AC RMS measurement mode
PK—Peak measurement mode
MX—Max hold value
MN—Min hold value
SP—Relative setpoint value
LED annunciators:
Relative reading mode
Alarm active
Remote IEEE-488 operation
Keypad: 22 full-travel keys
Front panel features: Display prompts, front panel lockout, and brightness control

Interfaces

RS-232C
Baud: 9600, 19200, 38400, and 57600
Update rate: 30 rdg/s (ASCII)
Software support: LabVIEW™ driver
Connector: 9-pin D-style, DTE configuration

IEEE-488.2
Capabilities: SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT1, C0, and E1
Update rate: 30 rdg/s
Software support: LabVIEW™ driver

Alarm
Settings: High/low setpoint, inside/outside, and audible
Actuators: LED annunciator, beeper, and relays

Relays
Number: 2
Contacts: Normally open (NO), normally closed (NC), and common (C)
Contact rating: 30 VDC at 2 A
Operation: Follows alarm or operated manually
Connector: Shared 25-pin I/O connector

Voltage Output 1
Configuration: Real-time analog voltage output of wide band AC signal
Range: ±3.5 V
Scale: ±3.5 V = ±full scale on selected range
Frequency response: 10 Hz to 20 kHz (wide band AC)
Accuracy: Probe dependent
Noise: ±1.0 mV RMS
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: Shared 25-pin I/O connector

Voltage Output 2
Configuration: Voltage output of field value, generated by DAC
Range: ±5 V
Scale: ±3.5 V = ±full scale on selected range
Resolution: 16-bit, 0.15 mV
Update rate: 40,000 updates/s
Accuracy: ±10 mV
Noise: ±0.3 mV RMS
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: Shared 25-pin I/O connector

Voltage Output 3
Configuration: Voltage output of compensated DC or RMS field value, generated by DAC
Range: ±10 V
Scale: User specified (defaults same as voltage output 2)
Resolution: 16-bit, 0.3 mV
Update rate: 30 updates/s
Accuracy: ±2.5 mV
Noise: ±0.3 mV RMS
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: Shared 25-pin I/O connector

General

Ambient temperature: 15 °C to 35 °C at rated accuracy, 5 °C to 40 °C with reduced accuracy
Power requirement: 100, 120, 220, and 240 VAC (+6%, -10%), 50 Hz or 60 Hz, 20 VA
Size: 216 mm W × 89 mm H × 318 mm D (8.5 in × 3.5 in × 12.5 in), half rack
Weight: 3 kg (6.6 lb)
Approval: CE mark

Probes and Extensions
Probe compatibility: Full line of standard and custom probes available (not compatible with Model 450/421 probes)—see page 13 for included (additional standard probes available)
Hall sensor compatibility: Front panel programmable sensitivity and serial number for user-supplied Hall sensor
Extension cable compatibility: Calibrated or uncalibrated probe extension cables with an EEPROM are available from 10 ft to 100 ft

Lake Shore calibrated extension cables maintain the same accuracy as the Model 455 probe.

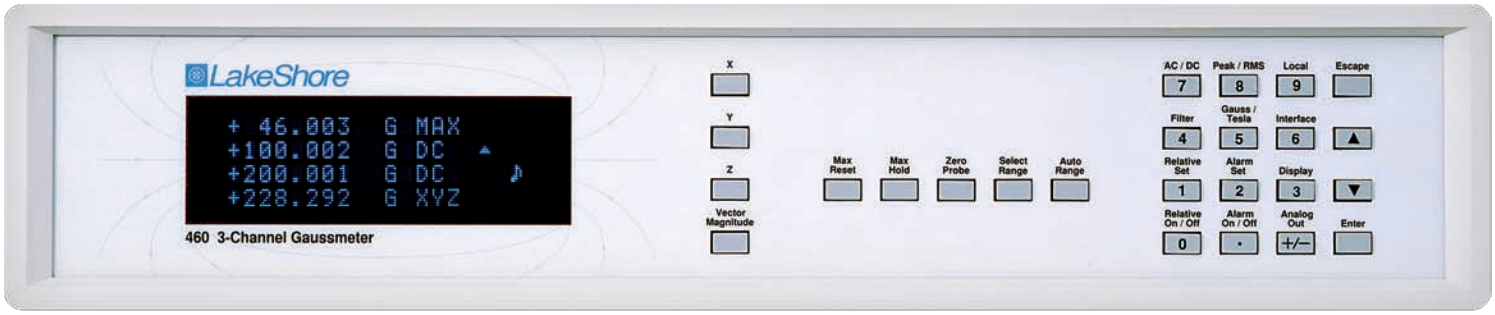
The uncalibrated version requires the operator to load the matching probe data file into the cable PROM directly from the Model 455 front panel. Additional errors caused by the uncalibrated extension cables are ±0.02% of field reading error and 1 °C temperature reading error.

Ordering Information

Part number	Description
455	Model 455 DSP gaussmeter
455-HMXX-XXXX-XX	Model 455 DSP gaussmeter with standard probe choice *—specify selected probe number for HMXX-XXXX-XX (see list on page 13)*
Specify line power option	
VAC-100	100 VAC configured, includes U.S. power cord
VAC-120	120 VAC configured, includes U.S. power cord
VAC-220	220 VAC configured, includes universal Europe power cord
VAC-240	240 VAC configured, includes universal Europe power cord
VAC-120-ALL	120 VAC configured, includes U.S. and universal Europe power cords and all fuses
Accessories included	
106-253	I/O mating connector
106-264	I/O mating connector shell
4060	Zero gauss chamber
MAN-455	Model 455 user manual
Accessories available	
4005	1 m (3.3 ft) long IEEE-488 (GPIB) computer interface cable assembly—includes extender required for simultaneous use of IEEE cable and auxiliary I/O connector
4065	Large zero gauss chamber for gamma probe
HMCBL-6	User programmable cable with EEPROM (1.8 m [6 ft])
HMCBL-20	User programmable cable with EEPROM (6.1 m [20 ft])
HMPEC-10	Probe extension cable with EEPROM (3 m [10 ft]), calibrated
HMPEC-10-U	Probe extension cable with EEPROM (3 m [10 ft]), uncalibrated
HMPEC-25	Probe extension cable with EEPROM (7.6 m [25 ft]), calibrated
HMPEC-25-U	Probe extension cable with EEPROM (7.6 m [25 ft]), uncalibrated
HMPEC-50	Probe extension cable with EEPROM (15 m [50 ft]), calibrated
HMPEC-50-U	Probe extension cable with EEPROM (15 m [50 ft]), uncalibrated
HMPEC-100	Probe extension cable with EEPROM (30 m [100 ft]), calibrated
HMPEC-100-U	Probe extension cable with EEPROM (30 m [100 ft]), uncalibrated
RM-½	Rack mount kit for one ½-rack gaussmeter in 483 mm (19 in) rack
RM-2	Rack mount kit for two ½-rack gaussmeters in 483 mm (19 in) rack
Calibration services	
CAL-N7-DATA	New instrument calibration for Model 455/475 with certificate and data
CAL-455-CERT	Instrument recalibration with certificate
CAL-455-DATA	Instrument recalibration with certificate and data

All specifications are subject to change without notice
Custom probes available — consult Lake Shore

Model 460 3-Channel Gaussmeter



- Can be operated with three individual probes, a single 2-axis probe and one individual probe, or a single 3-axis probe
- Displays each axis simultaneously
- Vector magnitude reading
- Resolution to 5¾ digits (1 part out of ±300,000)
- Accuracy to ±0.10% of reading
- Peak capture
- Analog voltage outputs
- IEEE-488 and serial interface

Product Description
The Model 460 3-channel Hall effect gaussmeter is the best choice for applications requiring 3-axis measurements or three simultaneous single axis measurements. The Model 460 combines the performance of three gaussmeters into one package, making it an excellent value for materials analysis and field mapping applications. The large vacuum fluorescent display shows readings for all three channels simultaneously as well as vector magnitude or differential readings. The full-function keypad provides easy access to measurement features.

Measurement Modes
The Model 460 operates in DC, RMS, and Peak modes, with superior accuracy and resolution in DC measurement mode. Measurements to 5¾ digits are possible due to the low noise floor. With low noise and high stability, the Model 460 is ideal for multiple-axis field mapping applications. Changing fields that are often used in material analysis systems can be measured on all three inputs up to 18 times per second over the computer interface, with excellent resolution.

Best suited for fringe field measurements or measurement of magnets and solenoids driven at line frequency, RMS mode measures periodic AC fields from 10 Hz to 400 Hz. Instrument circuitry accommodates wave forms with crest factors up to 7, with true RMS conversion.

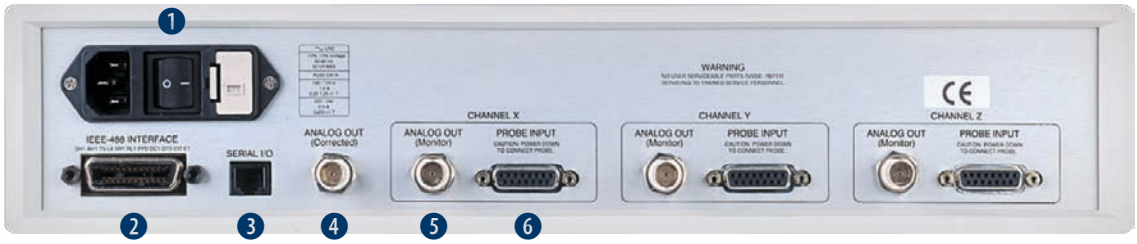
Peak circuitry in the Model 460 captures single event peaks or monitors the peak amplitude of periodic wave forms from 10 Hz to 400 Hz, with reproducible single peak measurements down to 5 ms rise time. Instrument software accommodates indefinite hold time with no decay. The Model 475 DSP gaussmeter is a good choice if faster peak or RMS measurements are required.

Range and Resolution
When used with appropriate probes, the Model 460 3-channel gaussmeter offers full scale ranges from 300 mG to 300 kG. A different range can be used with each input. With 5¾-digit resolution, DC field variations approaching 0.010 mG can be detected; in larger DC fields, resolution to one part in 300,000 is possible. For RMS and Peak measurement, resolution is 4¾ digits or one part in 30,000 because in these modes environmental noise is more difficult to separate from the desired signal. The filter feature of the Model 460 improves resolution in noisy environments by taking a running average of field readings. DC mode requires filtering to achieve 5¾-digit resolution.

Interface
The Model 460 is equipped with both parallel (IEEE-488) and serial (RS-232C) computer interfaces for command and data exchange; maximum reading rate can be achieved with the IEEE-488 interface. Nearly every function on the Model 460 front panel can be performed via computer interface. The Model 460 also includes one corrected and three monitor analog voltage outputs. Corrected for sensor linearity, offset, and temperature effects, the corrected output is a DC voltage proportional to the display reading. It is generated by a digital-to-analog converter programmed at the update rate of the Model 460, with software error correction. Corrected output is compatible with the Model 460 vector calculation software. The three monitor outputs are real time analog voltages proportional to each input's field; uncorrected, they provide output across the full DC to 400 Hz bandwidth at real-time speed.

Model 460 Rear Panel

1. Line input assembly
2. IEEE-488 interface
3. Serial I/O interface
4. Corrected analog output
5. Monitor analog outputs
6. Probe inputs



Display

The Model 460 has a 4-line by 20-character vacuum fluorescent display. During normal operation, the display is used to report field readings and give results of other features such as max/min or relative. When setting instrument parameters, the display gives the operator meaningful prompts and feedback to simplify operation. The operator can also control display brightness.

Following are four examples of the various display configurations:

Normal Reading—*the display configured to show the live DC field readings for the X, Y, and Z axis, as well as the vector magnitude*

Max DC Hold On—*the display configured to show the live DC field readings for the X, Y, and Z axis, as well as the maximum field reading (settable to any axis)*

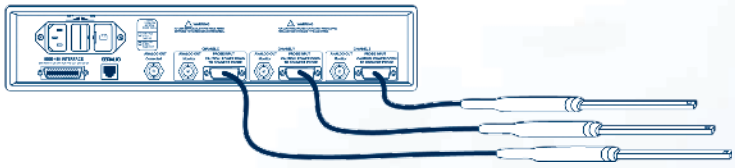
Differential Reading On—*the display configured to show the live DC field readings for the X and Y axis, as well as the X-Y axis differential reading*

3 Separate Probe Readings On—*the display configured to show the X, Y, and Z axis as three separate gaussmeters: the X axis as a DC field reading with audible and visual alarm, the Y axis as an RMS field value, and the Z axis as a peak field value*

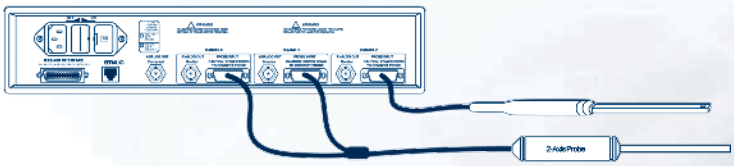
Probes and Sensors

Lake Shore offers an extensive line of single, two-, and three-axis probes, standard Hall sensors, and probe accessories. Lake Shore probes are factory calibrated for accuracy and interchangeability. Factory-calibrated probes feature a PROM in the probe connector so that calibration data can be read automatically by the instrument. If the probe is equipped with a temperature sensor, the Model 460 reads both temperature and field signal and continuously adjusts the calculated field value. The customer can also download sensitivity for discrete Hall sensors. In addition, Lake Shore can custom design probes and assemblies to meet specific application needs.

Model 460 Rear Panel Configurations



Model 460 configured as 3 separate gaussmeters



Model 460 configured as a 2-axis and single axis gaussmeter

Model 460 configured as a 3-axis gaussmeter

Model 460 Specifications

General Measurement

Number of inputs: 3
Update rate: Up to 4 rdg/s on display; up to 18 rdg/s with IEEE-488 interface
Measurement modes: DC, RMS, Peak
Probe compatibility: Standard, multi-axis, and custom probes
Probe features: Linearity Correction, Temperature Correction, Auto Probe Zero
Measurement features: Autorange, Max Hold, Relative Mode, Filter, Vector Magnitude, Differential Reading
Probe connector: 15-pin D style

DC Measurement

Probe type Range	5¾ digits with filter	4¾ digits without filter
HST Probe		
300 kG	0.001 kG	0.01 kG
30 kG	0.0001 kG	0.001 kG
3 kG	0.00001 kG	0.0001 kG
300 G	0.001 G	0.01 G
HSE Probe		
30 kG	0.0001 kG	0.001 kG
3 kG	0.00001 kG	0.0001 kG
300 G	0.001 G	0.01 G
30 G	0.0001 G	0.001 G
UHS Probe		
30 G	0.0001 G	0.001 G
3 G	0.00001 G	0.0001 G
300 mG	0.001 mG	0.01 mG

DC accuracy: ±0.10% of reading ±0.005% of range
DC temperature coefficient: ±0.05% of reading ±0.003% of range per °C

AC RMS and Peak Measurement

AC display resolution: 4¾ digits

Probe type Range	RMS resolution	Peak resolution
HST Probe		
300 kG	0.01 kG	0.01 kG
30 kG	0.001 kG	0.001 kG
3 kG	0.0001 kG	0.0001 kG
300 G	0.01 G	×
HSE Probe		
30 kG	0.001 kG	0.001 kG
3 kG	0.0001 kG	0.0001 kG
300 G	0.01 G	0.01 G
30 G	0.001 G	×
UHS Probe		
30 G	0.001 G	0.001 G
3 G	0.0001 G	0.0001 G
300 mG	0.01 mG	×

AC frequency range: 10 Hz to 400 Hz
AC RMS accuracy: ±2% of reading (50 Hz to 60 Hz)
AC RMS frequency response: 0 to -3.5% of reading (10 Hz to 400 Hz)
(All AC RMS specifications for sinusoidal input >1% of range)
AC peak accuracy: ±5% typical
AC peak speed: 5 ms for single peak

Front Panel

Display type: 4-line × 20-character, vacuum fluorescent
Display resolution: Up to ±5¾ digits
Display update rate: 4 rdg/s with vector off, 3 rdg/s with vector on
Displays units: Gauss (G), tesla (T)
Units multipliers: μ, m, k
Annunciators: RMS: AC input signal, DC: DC input signal, MAX: max hold value, s: relative reading, R: remote operation, ♪: alarm on
Keypad: 25 full-travel keys
Front panel features: Display prompts, front panel lockout, brightness control

Interfaces

RS-232C capabilities
- **Baud:** 300, 1200, 9600
- **Connector:** RJ-11 configuration
- **Update rate:** Up to 14 rdg/s at 9600 baud

IEEE-488 capabilities
- Complies with IEEE-488.2 SH1, AH1, SR1, RL1, PP0, DC1, DT0, C0, E1
- **Update rate:** 18 rdg/s with vector off, 14 rdg/s with vector on

Alarm
- **Settings:** High and low setpoint, inside/outside, audible
- **Actuators:** Display annunciator, beeper

Monitor analog output (3)
- **Configuration:** Real time analog voltage output
- **Scale:** ±3 V = ±full scale on selected range
- **Frequency response:** DC to 400 Hz
- **Accuracy:** Probe dependent
- **Minimum load resistance:** 1 kΩ (short circuit protected)
- **Connector:** BNC

Corrected analog output (1)
- **Configuration:** Voltage output generated by DAC
- **Range:** ±3 V; ±10 V for the Model 460-10
- **Scale:** User-defined
- **Resolution:** 0.366 mV of ±3 V
- **Update rate:** Same as field measurement
- **Accuracy:** ±0.1% full scale in addition to measurement error
- **Minimum load resistance:** 1 kΩ (short circuit protected)
- **Connector:** BNC

General

Ambient temperature: 15 to 35 °C at rated accuracy; 5 to 40 °C with reduced accuracy
Power requirement: 100, 120, 220, 240 VAC (+5%, -10%), 50 or 60 Hz, 40 VA
Size: 432 mm W × 89 mm H × 368 mm D (17 in × 3.5 in × 14.5 in), full rack
Weight: 7.5 kg (16.5 lb)
Approval: CE mark

Ordering Information

Part number	Description
460	Model 460 gaussmeter
460-10	Model 460 gaussmeter with corrected analog output set to ±10 V instead of ±3 V
Specify line power option	
VAC-100	100 VAC, includes U.S. power cord
VAC-120	120 VAC, includes U.S. power cord
VAC-220	220 VAC, includes universal Europe power cord
VAC-240	240 VAC, includes universal Europe power cord
VAC-120-ALL	120 VAC, includes U.S. & universal Europe power cords & all fuses
Accessories included	
115-006	Detachable line cord (U.S.)
115-007	Detachable line cord (Europe)
4060	Zero gauss chamber
MAN-460	Model 460 user manual
Accessories available—also see Gaussmeter Accessories section	
4001	RJ-11 4-wire cable assembly used with RS-232C interface—cable is 4.3 m (14 ft) long
4002	RJ-11 to DB-25 adapter—connects computer to RS-232C port
4003	RJ-11 to DE-9 adapter—connects computer to RS-232C port
4004	IEEE-488 interface cable connects customer-supplied computer to IEEE-488 interface—cable is 1 m (3.3 ft) long
CAL-460-CERT	Instrument recalibration with certificate
CAL-460-DATA	Instrument recalibration with certificate and data
CAL-N6-DATA	Calibration data for a new Model 460
RM-1	Rack mounting shelf to attach one Model 460 gaussmeter to a 483 mm (19 in) rack mount space

All specifications are subject to change without notice
Probes ordered separately (see page 26)
Custom probes available — consult Lake Shore

Model 421 Gaussmeter

- Resolution to 4¾ digits (1 part out of ±30,000)
- Large vacuum fluorescent display
- Serial interface
- Analog voltage outputs
- Sort function (displays Pass/Fail message)
- Alarm with relay

Product Description
The Model 421 Hall effect gaussmeter is Lake Shore's answer to the need for high performance at an affordable price in the rapidly changing permanent magnet industry. The Model 421 offers faster update, higher resolution, and more repeatable flux density measurements to meet the demands of manufacturing, quality assurance and R&D. As an added advantage, the Model 421 includes one of Lake Shore's Hall probes.

Performance
High-performance instrumentation is no longer the exclusive domain of research laboratories. Performance requirements are tightening in every magnetic measurement application. In response, the Model 421 offers improved accuracy, resolution, noise floor, and update rate.

Throughput
Throughput involves much more than update rate of an instrument. Usability of an instrument is just as important. The Model 421 has a large, bright, vacuum fluorescent display that can be seen easily in any lighting condition. The display updates quickly for fast feedback of probe or magnet positioning. The operation is straightforward with display prompts for the user. Max Hold, Alarm, and Sort features are included to streamline sorting and testing operations.

Automation
The Model 421 has a variety of interface features that are compatible with automated test configurations. The RS-232C serial computer interface can perform nearly every function of the instrument front panel. Two analog voltage outputs and an alarm relay facilitate automation without a computer.

Probes
The Model 421 is compatible with most Lake Shore gaussmeter Hall probes. When ordering the Model 421 with one of the gaussmeter Hall probes on the following page, a discounted package price is available. Lake Shore probes are factory calibrated for accuracy and interchangeability. Factory-calibrated probes feature a programmable read-only memory (PROM) in the probe connector so that calibration data can be read automatically by the instrument. Lake Shore can also custom design a probe to meet your specific application requirements.

Display
The Model 421 has a 2-line by 20-character vacuum fluorescent display. During normal operation, the display is used to report field readings and give results of other features such as max/min or relative. When setting instrument parameters, the display gives the operator meaningful prompts and feedback to simplify operation. The operator can also control display brightness.

Following are four examples of the various display configurations:

***Normal Reading**—the default mode with the display of the live DC field reading.*

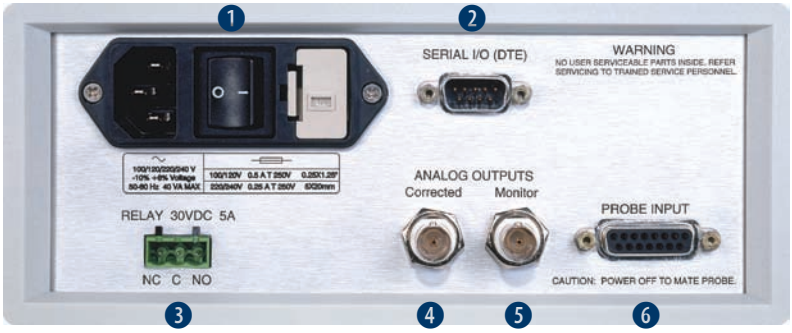
***Max DC Hold On**—the maximum value is shown in the lower display while the upper display contains the live DC field reading.*

***Alarm On**—the alarm gives an audible and visual indication when the field value is selectively outside or inside a user specified range. An output relay facilitates pass/fail actuation.*

***Sort On**—the live reading is shown in the upper display while the lower display contains the pass/fail (repetitive sorting or testing) message.*

Model 421 Rear Panel

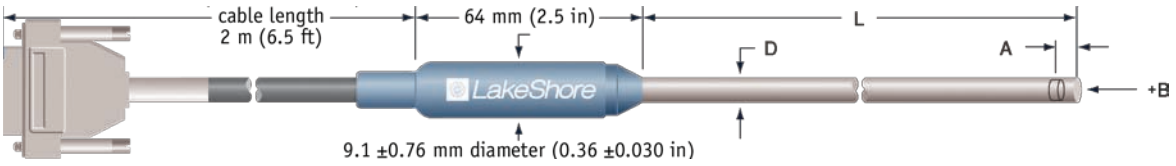
1. Line input assembly
2. Serial I/O interface (DTE)
3. Relay terminals
4. Corrected analog output
5. Monitor analog output
6. Probe input



Gaussmeter Hall Probes

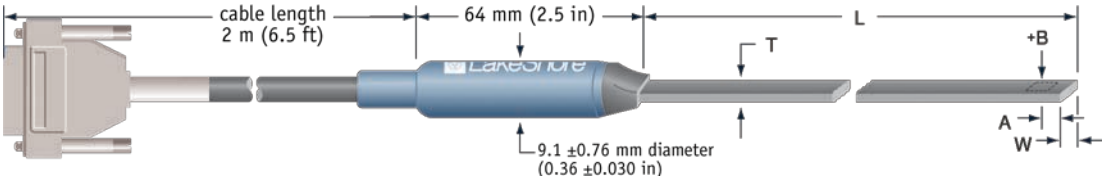
The Model 421 includes one of the Lake Shore probes listed below—specify probe model number when ordering. See page 26 for details on properly selecting a probe and for a complete listing of available probe models.

Axial Probes



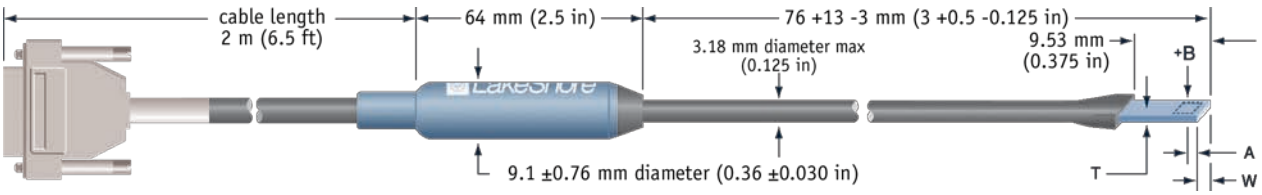
	L	D	A	Active area	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration
MMA-2502-VH	2 in ±0.063 in	0.25 in dia ±0.006 in	0.015 in ±0.005 in	0.030 in dia (approx)	Aluminum	DC and 10 Hz to 400 Hz	30 G, 300 G, 3 kG, 30 kG	±0.25% to 30 kG	0 °C to +75 °C	±0.09 G/°C	-0.04%/°C
MNA-1904-VH	4 in ±0.125 in	0.187 in dia ±0.005 in	0.005 in ±0.003 in		Fiberglass epoxy						
MMA-2502-VG	2 in ±0.063 in	0.25 in dia ±0.006 in	0.015 in ±0.005 in		Aluminum		300 G, 3 kG, 30 kG	±0.15% to 30 kG		±0.13 G/°C	-0.005%/°C
MNA-1904-VG	4 in ±0.125 in	0.187 in dia ±0.005 in	0.005 in ±0.003 in		Fiberglass epoxy						

Transverse Probes



	L	T	W	A	Active area	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration
MMT-6J04-VH	4 in ±0.125 in	0.061 in max	0.180 in ±0.005 in	0.150 in ±0.050 in	0.040 in dia (approx)	Aluminum	DC and 10 Hz to 100 Hz	30 G, 300 G, 3 kG, 30 kG	±0.25% to 30 kG	0 °C to +75 °C	±0.09 G/°C	-0.04%/°C
MNT-4E04-VH	4 in ±0.125 in	0.045 in max	0.150 in ±0.005 in			Rigid glass epoxy	DC and 10 Hz to 400 Hz					
MMT-6J04-VG	4 in ±0.125 in	0.061 in max	0.180 in ±0.005 in			Aluminum	DC	300 G, 3 kG, 30 kG	±0.15% to 30 kG		±0.13 G/°C	-0.005%/°C
MNT-4E04-VG	4 in ±0.125 in	0.045 in max	0.150 in ±0.005 in			Rigid glass epoxy	DC and 10 Hz to 400 Hz					

Flexible Transverse Probes



	W	T	A	Active area	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration
MFT-3E03-VH	0.135 in max	0.025 in max	0.125 in ±0.005 in	0.040 in dia (approx)	Flexible plastic tubing	DC and 10 Hz to 400 Hz	30 G, 300 G, 3 kG, 30 kG	±0.25% to 30 kG	0 °C to +75 °C	±0.09 G/°C	-0.04%/°C
MFT-3E03-VG							300 G, 3 kG, 30 kG	±0.15% to 30 kG		±0.13 G/°C	-0.005%/°C

Model 421 Specifications

General Measurement

Number of inputs: 1
Update rate: 5 rdg/s on display; up to 18 rdg/s with serial interface
Probe compatibility: Standard and custom probes, including Model 420 and 450 probes
Probe features: Linearity Correction, Auto Probe Zero
Measurement features: Autorange, Max Hold, Relative Mode, Filter
Probe connector: 15-pin D style

DC Measurement

DC display resolution: 4¾ digits with filter, 3¾ digits without filter

Probe type Range	Resolution with filter	Resolution without filter
HST Probe		
300 kG	0.01 kG	0.1 kG
30 kG	0.001 kG	0.01 kG
3 kG	0.0001 kG	0.001 kG
300 G	0.01 G	0.1 G
HSE Probe		
30 kG	0.001 kG	0.01 kG
3 kG	0.0001 kG	0.001 kG
300 G	0.01 G	0.1 G
30 G	0.001 G	0.01 G
UHS Probe		
30 G	0.001 G	0.01 G
3 G	0.0001 G	0.001 G
300 mG	0.01 mG	0.1 mG

DC accuracy: ±0.20% of reading ±0.05% of range
DC temperature coefficient: ±0.05% of reading ±0.03% of range per °C

AC RMS Measurement

AC display resolution: 3¾ digits

Probe type Range	Resolution
HST probe	
300 kG	0.1 kG
30 kG	0.01 kG
3 kG	0.001 kG
300 G	0.1 G
HSE probe	
30 kG	0.01 kG
3 kG	0.001 kG
300 G	0.1 G
30 G	0.01 G
UHS probe	
30 G	0.01 G
3 G	0.001 G
300 mG	0.1 mG

AC frequency range: 10 Hz to 400 Hz
AC accuracy: ±2% of reading (50 Hz to 60 Hz)
AC frequency response: 0 to -3.5% of reading (10 Hz to 400 Hz)
(All AC specifications for sinusoidal input >1% of range)

Front Panel

Display type: Large 2-line × 20-character vacuum fluorescent display
Display resolution: To ±4¾ digits
Display update rate: 5 rdg/s
Display units: Gauss (G), tesla (T)
Units multipliers: μ, m, k
Annunciators: RMS: AC input signal, DC: DC input signal, MAX: max hold value, s: relative reading, R: remote operation, ♪: alarm on
Keypad: 12-key membrane
Front panel features: Display prompts, front panel lockout, brightness control

Interfaces

RS-232C capabilities
Baud: 300, 1200, 9600
Connector: DE-9, DTE configuration
Software support: LabVIEW™ driver (consult Lake Shore for availability); compatible with Model 420 command set

Alarm
Settings: High and low setpoint, Inside/Outside, Audible, Sort
Actuators: Display annunciator, sort message, beeper, relay

Relay
Number: 1
Contacts: Normally open (NO), normally closed (NC) and common (C)
Contact rating: 30 VDC at 2 A
Operation: Follows alarm
Connector: Detachable terminal block

Monitor analog output
Configuration: Real time analog voltage output
Range: ±3 V
Scale: ±3 V = ±full scale on selected range
Frequency response: DC to 400 Hz
Accuracy: Probe dependent
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: BNC

Corrected analog output
Configuration: Voltage output generated by DAC
Range: ±3 V
Scale: ±3 V = ±full scale on selected range
Resolution: 1.25 mV
Update rate: 5 updates/s
Accuracy: ±0.35%
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: BNC

General

Ambient temperature: 15 to 35 °C at rated accuracy; 5 to 40 °C with reduced accuracy
Power requirement: 100, 120, 220, 240 VAC (+5%, -10%), 50 or 60 Hz, 20 VA
Size: 216 mm W × 89 mm H × 318 mm D (8.5 in × 3.5 in × 12.5 in), half rack
Weight: 3 kg (6.6 lb)
Approval: CE mark

Ordering Information

Part number	Description
421	Model 421 gaussmeter plus one probe
421-MXX-XXXX-XX	Model 421 gaussmeter with standard probe—specify selected probe number for MXX-XXXX-XX (see list on page 20)

Specify line power option

VAC-100	100 VAC, includes U.S. power cord
VAC-120	120 VAC, includes U.S. power cord
VAC-220	220 VAC, includes universal Europe power cord
VAC-240	240 VAC, includes universal Europe power cord
VAC-120-ALL	120 VAC, includes U.S. & universal Europe power cords & all fuses

Accessories included

106-741	Terminal block for relay outputs
115-006	Detachable line cord (U.S.)
115-007	Detachable line cord (Europe)
4060	Zero gauss chamber
MAN-421	Model 421 user manual

Accessories available

106-741	Terminal block mating connector: 3-pin connector for alarm relay
CAL-421-CERT	Instrument recalibration with certificate
CAL-421-DATA	Instrument recalibration with certificate and data
CAL-N5-DATA	Calibration data for a new Model 421
RM-½	Rack mount kit for one ½-rack gaussmeter in 483 mm (19 in) rack
RM-2	Rack mount kit for two ½-rack gaussmeter in 483 mm (19 in) rack

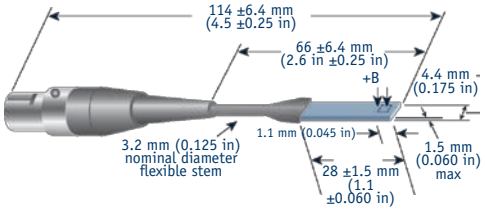
All specifications are subject to change without notice
Custom probes available — consult Lake Shore

Model 410 Gaussmeter

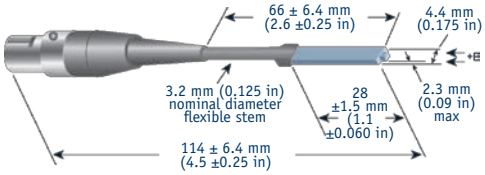
- Handheld
- Resolution to 3½ digits (1 part out of ±2000)
- Ranges (Autoranging): ±200 G, ±2 kG, and ±20 kG ranges
- Accuracy: ±2% of reading
- Frequency response: DC and 20 Hz to 10 kHz
- Front panel key functions include Max Hold, Relative, Alarm, Filter
- Custom liquid crystal display

The Model 410 is a handheld gaussmeter designed for accurate magnetic field measurements from 0.1 G to 20 kG (0.01 mT to 2 T). Most operating functions can be selected via the front panel keypad with one or two keystrokes. The Model 410 displays in gauss or tesla, AC or DC magnetic field values with resolution to 100 mG. Operating functions include Max Hold, Filter, Relative Reading, Zero Probe, and an audible Alarm.

Model 410 shown in the 4107 bench support



Transverse Probe—The transverse probe measures magnetic fields perpendicular to the probe axis.



Axial Probe—The axial probe has the Hall sensor mounted perpendicular to the probe axis and measures magnetic fields parallel to the probe axis.

Max Hold—The largest field magnitude measured (since the last reset) is displayed with the Max Hold function.

Filter—When the field being measured is noisy, using the Filter function will average readings to produce a more stable display.

Alarm—An audible alarm is sounded and the display indicator flashes when the measured field is higher than the keypad-entered alarm point.

Zero Probe—Used to eliminate probe offsets and small external fields.

Relative Reading—Used to show small variations in large background fields. When activated, Relative function displays deviation from a specific setpoint.

Autoranging—Automatically selects the appropriate range.

Memory Hold—On power down the Model 410 stores the complete instrument configuration in nonvolatile memory, including the calibration number and probe offset, making it unnecessary in most cases to go through a setup procedure on power up.

Model 410 Specifications

Display: Digital liquid crystal display (LCD), 3½ digits
Resolution: 0.1 G on the 200 G range
DC accuracy: 2% reading ±0.1% full scale (at 25 °C) —includes instrument, probe, and a calibration transfer
AC accuracy: ±5% of reading
Frequency response: DC and 20 Hz to 10 kHz
Ranges: ±200.0 G (±20.00 mT); ±2.000 kG (±200.0 mT); ±20.00 kG (±2.000 T)
Temperature range: 0 °C to 50 °C (operating)
Instrument temperature coefficient: 0.05% rdg/°C
Instrument and probe temperature coefficient: 0.1% rdg/°C
Weight: 0.45 kg (1 lb)
Size: 193 mm H × 99 mm W × 43.2 mm D (7.6 in × 3.9 in × 1.7 in)
Power: 4 AA battery operated (battery life > 160 h)
Approval: CE mark

Ordering Information

Part number	
410-SCT	410 in soft case with a transverse probe
410-SCA	410 in soft case with an axial probe
410-SCAT	410 in soft case with a transverse and axial probe
410-HCAT	410 in a hard case with a transverse and axial probe

Accessories included

MST-410/MSA-410	Transverse and/or axial probe
MPEC-410-3	Extension cable
4106	Set of 4 AA batteries
4102	Model 410 user manual

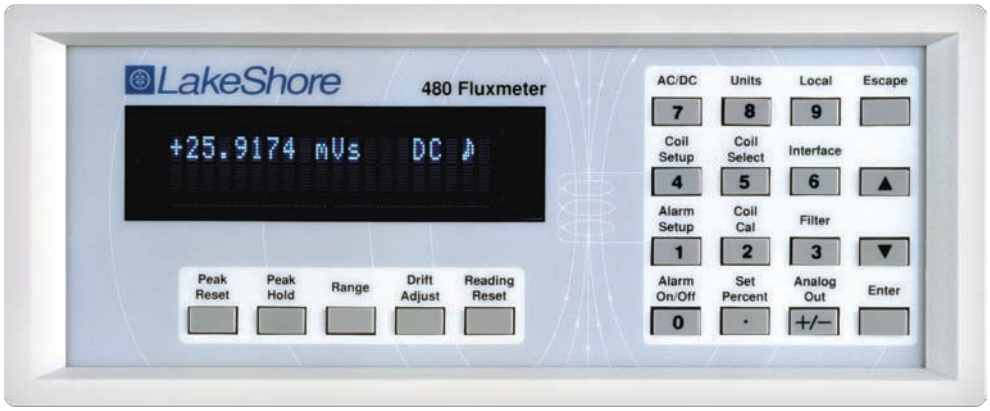
Accessories available

4060	Zero gauss chamber
4106	Set of 4 AA batteries
4107	Model 410 bench support
4141	Soft case
4142	Hard case
CAL-410-CERT	Instrument recalibration with certificate
CAL-410-DATA	Instrument recalibration with certificate and data
CAL-N1-DATA	Calibration data for a new Model 410
MSA-410	Axial probe for Model 410
MST-410	Transverse probe for Model 410
MSA-2202-410	51 mm (2 in) brass axial probe for Model 410
MSA-2204-410	102 mm (4 in) brass axial probe for Model 410
MST-9P02-410	51 mm (2 in) brass transverse probe for Model 410
MST-9P04-410	102 mm (4 in) brass transverse probe for Model 410
MPEC-410-3	Probe extension cable, 1 m (3 ft)
MPEC-410-10	Probe extension cable, 3 m (10 ft)

All specifications are subject to change without notice

Model 480 Fluxmeter

- 5¾-digit DC resolution (1 part out of ±300,000)
- Automatic drift compensation
- Very fast peak capture
- AC frequency response to 50 kHz
- IEEE-488 and serial interfaces
- Storage of parameters for up to 10 existing coils



Product Description

An advanced tool designed primarily for use in industrial and measurement systems settings, the Model 480 fluxmeter measures total flux from which B, flux density, and H, magnetic field strength, can be determined. The Model 480 is valuable for magnetizing, manual and automated magnet testing and sorting, and as the main component in BH loop or hysteresis measurement system applications. The Model 480 is compatible with most sensing coils and fixtures.

Manual Magnet Testing

A bright display and fast update rate make the Model 480 ideal for manual magnet sorting and testing. The instrument's low drift improves productivity with fewer adjustments. Remote terminals allow for foot pedal reading reset to keep hands on the work, not the instrument. Configurable alarms give an audible signal or relay closure to signify pass/fail.

Automated Magnet Testing

In automated testing, time is money. The Model 480 has many features to enhance throughput. The instrument has a fast update rate and fast settling time. It recovers quickly from reading reset to start a new reading cycle. The IEEE-488 and serial computer interfaces included with the 480 can be used to control most instrument functions. Relays and analog outputs can be used for automation without a computer interface.

Magnetizing

The magnetizing process places unique demands on all associated electronics. The Model 480 responds with a very fast peak capture that can keep up with the fastest magnetizing pulses. Both a positive and negative peak can be captured from the same pulse. The input of the Model 480 is protected against the high voltages present during magnetizing.

Materials Analysis

High resolution and low drift define a fluxmeter's role in analytical measurement. The high resolution of the Model 480 is reinforced by a low noise floor. A configurable filter helps keep the readings quiet. Automatic and manual drift adjustment modes help optimize the integrators' low drift characteristics. The IEEE-488 and serial computer interfaces included with the 480 allow automated data taking.

AC Magnetic Fields

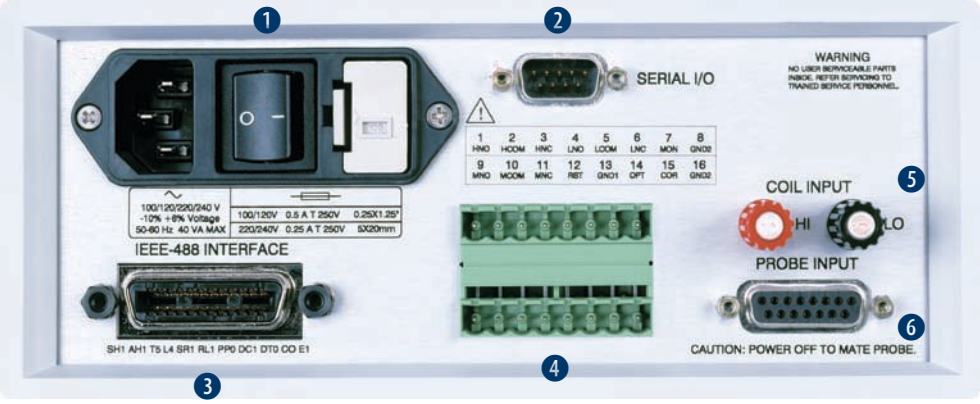
Sensing coils are sensitive to AC magnetic fields but many conventional integrating fluxmeters can not measure AC fields. The Model 480 has an AC mode that enables it to measure fields over a wide frequency range using simple sensing coils. Applications are limited to field volumes as large as or larger than the coil, but for some it is an inexpensive way to make low drift AC field measurements.

Drift Adjustment

Adjusting or nulling the drift of an analog integrator wastes time—it can be the only unpleasant part of using an integrating fluxmeter. Lake Shore innovation brings some relief. The Model 480 has a built-in drift algorithm that continually adjusts drift when the instrument and coil are idle. It is ready when you are to make precision low-drift measurements. The adjustment algorithm has no effect during flux integration. Manual drift adjustment is also available.

Model 480 Rear Panel

1. Line input assembly
2. Serial I/O interface
3. IEEE-488 interface
4. Terminal block (for relays and analog signals)*
5. Coil input for user coils
6. Probe input for Lake Shore probes



**The Model 480 terminal block has connections for external reset. With this feature, a foot pedal or programmable logic controller (PLC) can be used to start a new measurement cycle. The external reset is TTL-compatible and a logic low will activate a reset. The signal is internally pulled up to allow operation with a simple switch closure between pins 12 and 13.*

Display

The Model 480 has a 2-line by 20-character vacuum fluorescent display. During normal operation, the display is used to report field readings and give results of other features such as max/min or relative. When setting instrument parameters, the display gives the operator meaningful prompts and feedback to simplify operation. The operator can also control display brightness.

Following are three examples of the various display configurations:

***Normal Reading**—the default mode with the display of the live DC flux reading*

***DC Positive and Negative Peak On**—the display shows both the positive and negative DC peak readings*

***Alarm On**—the alarm gives an audible and visual indication of when the flux value is selectively outside or inside a user-specified range*

Helmholtz and Search Coils

Coils and probes wound by the user or from other manufacturers can be easily used with the Model 480. The Model 480 allows the user to save parameters for up to 10 existing coils/probes and quickly switch between them. Lake Shore also offers several sensing coils and probe assemblies for use with the Model 480 that have several conveniences. They are factory calibrated for accuracy and interchangeability. Calibration data is loaded into memory in the probe connector so it does not have to be entered by the user. Special coil assemblies are also available and can be designed to meet customer specifications.

FH-Series Helmholtz Coils

Lake Shore coils can be used with the Model 480 fluxmeter as well as with other fluxmeters. When used with a Model 480 fluxmeter, calibration and set up data are automatically loaded into the instrument. These probes and coils are accurately calibrated, using field standards maintained at Lake Shore. Most standards are traceable to physical standards such as a coil or probe of carefully controlled dimensions, or in some cases, to proton resonance. The coil constants are measured on the basis of the field generated by a current through the coil.

See pages 46 and 47 for more information about available Helmholtz and search coils.

Model 480 Specifications

Measurement

Number of inputs: 1
Input type: 2-lead, ground referenced
Input resistance: 100 kΩ or 10 kΩ
Maximum operating input voltage: 60 V
Absolute maximum input voltage: 100 V—**WARNING**—voltages between 60 V and 100 V will not damage the instrument but could result in personal injury or damage to other instruments
Update rate: 5 rdg/s display; 30 rdg/s IEEE-488; 30 rdg/s serial

DC

DC resolution: To 5¾ digits
DC integrator capacitance: 1 μF nominal

DC input resistance:	100 kΩ	100 kΩ	10 kΩ	10 kΩ
DC ranges:	300 mVs	30 mVs	30 mVs	3 mVs
DC resolution:	0.001 mVs	0.0005 mVs	0.0005 mVs	0.0005 mVs

DC accuracy: Offset: ±10 μVs ±DC integrator drift; gain: ±0.25% of reading (<10 Vs/s maximum rate of change)
DC minimum dΦ/dt: 20 μVs/min
DC maximum dΦ/dt: 60 Vs/s
DC integrator drift: ±1 μVs/min, 0.0004% full scale/min on 300 mVs range (100 kΩ input resistance constant temperature environment)

DC Peak

DC peak resolution: 4¾ digits
DC peak integrator capacitance: 1 μF nominal

DC peak input resistance:	100 kΩ	100 kΩ	10 kΩ	10 kΩ
DC peak ranges:	300 mVs	30 mVs	30 mVs	3 mVs
DC peak resolution:	0.01 mVs	0.001 mVs	0.001 mVs	0.001 mVs
DC peak minimum reading:	0.05 mVs	0.005 mVs	0.005 mVs	0.005 mVs

DC peak accuracy: Offset: ±100 μVs ±DC integrator drift; gain: ±5% of reading (<10 Vs/s maximum rate of change)
DC peak maximum dΦ/dt: 60 Vs/s
DC peak update rate: Reduces update rate to ¼ normal

AC

AC resolution: 4¾ digits (reduced to 3¾ digits on the 30 μVs range)
AC integrator capacitance: 0.1 μF nominal

AC input resistance:	100 kΩ	100 kΩ	100 kΩ	100 kΩ
AC ranges:	30 mVs	3 mVs	300 μVs	30 μVs
AC resolution:	0.001 mVs	0.0001 mVs	0.01 μVs	0.01 μVs
AC minimum reading:	3.000 mVs	0.3000 mVs	30.00 μVs	3.00 μVs

AC frequency response: 2 Hz to 50 kHz
AC accuracy: ±1% rdg ±10 μVs (10 Hz to 10 kHz sinusoidal); ±5% rdg ±10 μVs (2 Hz to 50 kHz sinusoidal)
AC integrator drift: NA

AC Peak

AC peak resolution: 3¾ digits
AC peak integrator capacitance: 0.1 μF nominal

AC input resistance:	100 kΩ	100 kΩ	100 kΩ
AC peak ranges:	30 mVs	3 mVs	300 μVs
AC peak resolution:	0.01 mVs	0.001 mVs	1 μVs
AC minimum reading:	0.01 mVs	0.001 mVs	5 μVs

AC peak accuracy: ±5% rdg ±10 μVs (10 Hz to 10 kHz sinusoidal); ±10% rdg ±10 μVs (2 Hz to 50 kHz sinusoidal)
AC peak update rate: Reduces update rate to ¼ normal

Front Panel

Display type: 2-line × 20-character vacuum fluorescent display
Display resolution: To ±5¾ digits
Display update rate: 5 rdg/s
Display units: Vs, MxN, WbN, VsΦ, MxΦ, WbΦ, G, T, Wbcm, A, %
Units multipliers: p, n, μ, m, k, M, G
Annunciators: AC—AC input signal, DC—DC input signal, ∧ ∨—positive and negative peaks, R—remote operation, ♪—alarm on
Keypad: 21 full-travel keys

Interfaces

IEEE-488.2 capabilities: SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT0, C0, E1
Serial interface: RS-232C electrical, DA-9 connector, 9600 baud
External reset type: Contact closure
Alarms
- **Number:** 2
- **Settings:** High and low setpoint, Inside/Outside, Audible
- **Actuators:** Display annunciator, beeper, relays

Relays
- **Number:** 3
- **Contacts:** Normally open (NO), normally closed (NC), and common (C)
- **Contact rating:** 30 VDC at 2 A
- **Operation:** Follow high, low alarms with third relay indicating no alarm state—can be operated manually
- **Connector:** Detachable terminal block

Monitor analog output
- **Scale:** ±3 V = ±full scale on Vs range
- **Accuracy:** ±1% of reading ±10 mV, (DC to 10 kHz); ±5% of reading ±10 mV, (10 kHz to 50 kHz)
- **Minimum load resistance:** 1 kΩ
- **Connector:** Detachable terminal block

Corrected analog output
- **Scale:** User selected
- **Range:** ±10 V
- **Resolution:** 0.3 mV
- **Accuracy:** ±2.5 mV
- **Minimum load resistance:** 1 kΩ
- **Connector:** Detachable terminal block

General

Ambient temperature: 15 °C to 35 °C at rated accuracy, 5 °C to 40 °C with reduced accuracy
Power requirement: 100, 120, 220, 240 VAC, +5% -10%, 50 or 60 Hz, 20 VA
Size: 216 mm W × 89 mm H × 318 mm D (8.5 in × 3.5 in × 12.5 in), half rack
Weight: 3 kg (6.6 lb)
Approval: CE mark

Ordering Information

Part number	Description
480	Model 480 fluxmeter
Specify line power option	
VAC-100	100 VAC, includes U.S. power cord
VAC-120	120 VAC, includes U.S. power cord
VAC-220	220 VAC, includes universal Europe power cord
VAC-240	240 VAC, includes universal Europe power cord
VAC-120-ALL	120 VAC, includes U.S. and universal Europe power cords and all fuses
Accessories included	
106-739	Two 8-pin terminal block mating connectors
MAN-480	Model 480 user manual
Accessories available	
4005	1 m (3.3 ft) long IEEE-488 (GPIB) computer interface cable assembly—includes extender required for simultaneous use of IEEE cable and auxiliary terminal block
CAL-480-CERT	Instrument recalibration with certificate
CAL-480-DATA	Instrument recalibration with certificate and data
CAL-N8-DATA	Calibration data for a new Model 480
RM-½	Rack mount kit for mounting one Model 480 in 483 mm (19 in) rack
RM-2	Rack mount hit for mounting two Model 480s in 483 mm (19 in) rack
Coils—see pages 46 and 47 for more information	
FNT-6R04-100	100 cm^2 search coil
FNT-5P04-30	30 cm^2 search coil
FH-2.5	Helmholtz coil, 64 mm (2.5 in) ID
FH-6	Helmholtz coil, 152 mm (6 in) ID
FH-12	Helmholtz coil, 305 mm (12 in) ID
FCBL-6	User programmable cable with PROM, 1.5 m (5 ft) long

All specifications are subject to change without notice
Custom probes/coils/fixtures available — consult Lake Shore

Gaussmeter Hall Probes

Characteristics to be Considered when Selecting a Probe

Proper selection of a Hall probe is probably the most difficult and important decision to make after choosing a gaussmeter. Using the improper probe could lead to less than optimal accuracy or, even worse, costly damage. Lake Shore offers a complete line of gaussmeter probes to work in a variety of magnetic measurement applications. Lake Shore probes are factory calibrated for accuracy and interchangeability. Factory-calibrated probes feature a programmable read-only memory (PROM) in the probe connector so that calibration data can be read automatically by the instrument. The next few pages will help you make an informed probe choice. If you have additional questions, contact Lake Shore and our experts can guide you through the selection process. Lake Shore can also custom design a probe to meet your specific application requirements.

Use these guidelines to help choose a probe:

- Choose a probe to match the application. Do not buy more accuracy, field range, or fragility than is actually needed.
- The thinner a probe, the more fragile it is. Try to avoid the temptation to select an easily damaged probe based on a possible, but not required, future application. For instance, avoid using an exposed-device probe such as a model MFT-3E03-type for general field measurements. Once a stem or sensor has been damaged, the probe is not repairable.
- Metal enclosed probes, such as the MMT-6J08 and MMA-2508 types offer good protection to the Hall sensor. Brass stem transverse probes are even more rugged than the aluminum type probes, and offer the greatest amount of protection.
- Be cautious about using aluminum stemmed, transverse probes, such as the MMT-6J08-type, where AC magnetic fields are to be measured. Eddy currents in the stem material can affect reading accuracy. A superior choice for AC measurements would be the MNT-4E04-type fiberglass-epoxy stem probes.
- Several stem lengths are offered for each probe type. User preference or test set-up dimensions usually determine the final selection. Longer stems are more susceptible to accidental bending (in many cases not catastrophic, but bothersome). Stem length does not affect performance.
- Be aware of the differences in the probe “active areas” shown on the data sheet. A Hall effect probe will indicate the average field value sensed over that total active area. Thus, when measuring magnetic fields with a high gradient across the sensor width, choose the smallest active area practical. Keep in mind the fragility rule (see the second bullet above).
- Lake Shore gaussmeter probes exhibit different ranges of magnetic fields over which they will provide valid readings. Check the specification sheet and the tables at the right for these usable ranges.
- If none of the standard probe configurations fit your needs, Lake Shore can provide custom probes to meet your physical, temperature, and accuracy requirements. Contact us with your special requirement details.

Usable Full-Scale Ranges vs. Probe Type for Model 475 and 455

HST-3	HST-4	HSE	UHS
—	—	—	35 mG
—	—	—	350 mG
—	—	3.5 G	3.5 G
35 G	35 G	35 G	35 G
350 G	350 G	350 G	—
3.5 kG	3.5 kG	3.5 kG	—
35 kG	35 kG	35 kG	—
350 kG	—	—	—

Usable Full-Scale Ranges vs. Probe Type for Models 460, 450, and 421

HST-1	HST-2	HSE-1	UHS-1
—	—	—	300 mG
—	—	—	3 G
—	—	30 G	30 G
300 G	300 G	300 G	—
3 kG	3 kG	3 kG	—
30 kG	30 kG	30 kG	—
300 kG	—	—	—

Magnitude
Typical Hall effect probes cover an operating range of 3 to 5 orders of magnitude. Operation beyond this field range requires some compromise in performance, often including higher noise or loss of resolution. Choosing the correct probe type ensures optimal performance in the desired measurement range.

High Stability (HST-1, HST-2, HST-3, HST-4):

With a high field range of up to 350 kG[1] (35 T), high stability probes are used when fields exceed the limit of other probe types. Their low field performance is slightly degraded with a minimum sensitivity of 50 mG (5 µT). HST probes are also inherently more temperature stable than other probes, and should be used when large temperature fluctuations are expected. They are offered in a variety of stem geometries.

High Sensitivity (HSE and HSE-1):

High sensitivity probes are the most common for general-purpose field measurement. They operate effectively in fields up to 35 kG[2] (3.5 T) with excellent sensitivity. At low fields, their sensitivity can be as low as 5 mG (0.5 µT). Convenient for many applications because of their relatively small active area, HSE probes are offered in the same geometries as HST probes.

Ultra High Sensitivity (UHS and UHS-1):

Low magnitude, large volume fields are most effectively measured with ultra high sensitivity probes, which have unbeatable low field resolution to 0.02 mG (2 nT). UHS probes, or gamma probes, are ideal for measuring fringe fields or variations in the earth's field. They should never be used in fields over 30 G. UHS probes are larger than other probes and have a very large active area, making them impractical for small volume fields or tight spaces.

Radiation Effects on Gaussmeter Hall Probes
The HST and HSE probes use a highly doped indium arsenide active material. The HST material is the more highly doped of the two and therefore will be less affected by radiation. Some general information relating to highly doped indium arsenide Hall generators is as follows:

- Gamma radiation seems to have little effect on the Hall generators
- Proton radiation up to 10 Mrad causes sensitivity changes less than 0.5%
- Neutron cumulative radiation (>0.1 MeV, 10^{15} per sq cm) can cause a 3% to 5% decrease in sensitivity

In all cases the radiation effects seem to saturate and diminish with length of time exposed

Orientation
Getting to the field is part of the challenge in selecting a probe. Field orientation dictates the most basic probe geometry choice of transverse versus axial. Other variations are also available for less common, more challenging applications. Listed below are the standard configurations for HSE and HST probes; UHS probes require special packaging that is not described here.

Transverse:

Transverse probes, most often rectangular in shape, measure fields normal to their stem width. They are useful for most general-purpose field measurements and are essential for work in magnet gaps. Several stem lengths and thicknesses are available as standard probes.

Axial:

Axial probes, usually round, measure fields normal to their end. They can also be used for general-purpose measurements, but are most commonly used to measure fields produced by solenoids. Several stem lengths and diameters are available as standard probes.

Flexible:

Flexible probes have a flexible portion in the middle of their stem, while the active area at the tip remains rigid and somewhat exposed. This unique feature makes them significantly more fragile than other transverse probes. Flexible probes should only be selected for narrow-gap measurement applications.

Tangential:

Tangential probes are transverse probes designed to measure fields parallel to and near a surface. The active area is very close to the stem tip. These probes are intended for this specific application and should not be selected for general transverse measurements.

Frequency
Hall effect gaussmeters are equally well suited for measuring either static, DC fields or periodic, AC fields, but proper probe selection is required to achieve optimal performance.

Metal Stem:

Metal stem probes are the best choice for DC and low frequency AC measurements. Non-ferrous metals are used for probe stems because they provide the best protection for the delicate Hall effect sensor without altering the measured field. Aluminum is the most common metal stem material, but brass can also be used. Metal stems do have one drawback: eddy currents are generated in them when they are placed in AC fields. These eddy currents oppose the field and cause measurement error. The error magnitude is proportional to frequency, and is most noticeable above 800 Hz.

[1] 350 kG with Models 475 and 455, 300 kG range with Models 460, 450, and 421
[2] 35 kG with Models 475 and 455, 30 kG range with Models 460, 450, and 421

Non-metal Stem:

Non-metal stems are required for higher frequency AC fields and for measuring pulse fields—fiberglass/epoxy is a common non-metal stem material. Alternatively, the Hall effect sensor can be left exposed on its ceramic substrate, which provides less protection for the sensor. Eddy currents do not limit the frequency range of these non-conductive materials, but other factors may.

Please note: No gaussmeter probe type is suitable for direct exposure to high voltage.

Gradient

Probe selection would be easier if all fields were large and uniform, but most fields are limited in volume and contain gradients (changes in magnitude). Hall effect probes measure an average magnitude over their active area, making it necessary to understand the relationship between active area and field gradients.

Severe field gradients are always experienced as the active sense element is moved away from a permanent magnet pole, making it important to know the distance between the active area and probe tip. The distance between probe tip and active area is specified for axial probes, but is less easily defined for transverse probes.

Nominal Active Area:

HSE and HST probes have a nominal active area on the order of 1 mm diameter, which is useful for all but the most stringent applications. The measured field is the average of the active area, but without severe gradients, therefore the measured value accurately represents the true field. Field mapping with standard probes is also practical if a mapping resolution of 1 mm or greater is acceptable.

Small Active Area:

HSE and HST probes with a smaller active area are also available from Lake Shore for measurements in severe gradients, or for high resolution mapping applications.

UHS Probes:

UHS probes have a very large active length, up to 3.5 in (89 mm). They are designed to measure very low magnitude, large volume ambient fields with little gradient.

Probe Durability

All Hall effect probes are fragile. The sensor, normally located at the tip of the probe stem, must not be bent, physically shocked, or abraded. It may be tempting to choose a probe with the thinnest transverse stem or smallest diameter axial stem; however, it is always best to choose the most robust probe that fits the immediate application. For example, the HMMT-6J04-VR (aluminum stem) is less prone to damage than the HMFT-3E03-VR (flexible stem), and the HMMA-2502-VR (1/4 in diameter aluminum) is more durable than the HMNA-1904-VR (3/16 in diameter fiberglass) with its exposed Hall sensor.

Note: never fasten a probe stem to another object. If a probe is clamped, always apply the clamp to the handle.

Polarity of Transverse Probes

The output will be positive when the direction of the flux density vector is into the Lake Shore logo (i.e., the logo is toward the north pole).

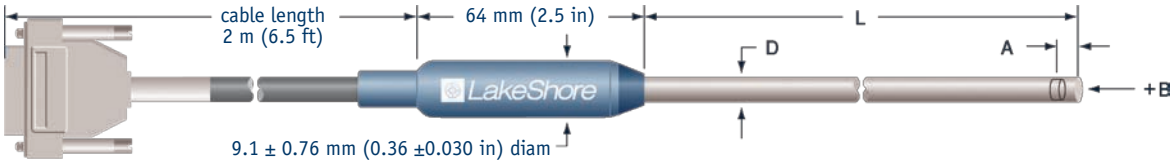
Polarity of Axial Probes

Except in rare, special cases, the output will be positive when the field vector is into the tip of the probe.

Definitions

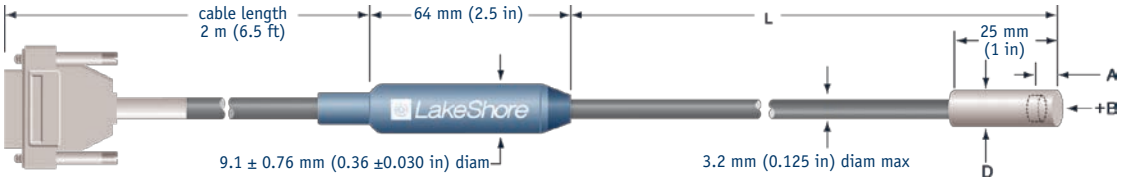
A	Distance from the tip of the probe to the center line of the active area
+B	Magnetic flux density vector (positive gaussmeter reading)

Axial Probes



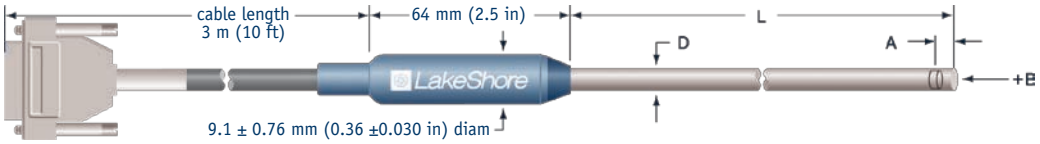
	L (in)	D (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg at 25 °C)	Operating temp range (°C)	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
for Models 475 and 455												
HMMA-0602-TH	2 ±0.125	0.060 dia +0.001 -0.003	0.005 ±0.003	0.020 dia (approx)	Aluminum	DC to 400 Hz	**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.25% to 10 kG	0 °C to +75 °C	±0.13 G/°C	±0.01%/°C	No
HMMA-0604-TH	4 ±0.125											
HMMA-0608-TH	8 ±0.125											
HMMA-0618-TH	18 ±0.125											
HMMA-0802-UH	2 ±0.125	0.080 dia ±0.005	0.010 ±0.005			DC		±0.25% to 20 kG				
HMMA-0804-UH	4 ±0.125											
HMMA-0808-UH	8 ±0.125											
HMNA-1902-VR	2 ±0.125	0.187 dia ±0.005	0.005 ±0.003	0.030 dia (approx)	Fiberglass epoxy	DC to 20 kHz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG and ±0.25% 30 to 35 kG		±0.09 G/°C	±0.015%/°C	Yes
HMNA-1904-VR	4 ±0.125											
HMNA-1908-VR	8 ±0.125											
HMMA-1802-VR	2 ±0.063	0.180 dia +0.002 -0.004	0.015 ±0.005		Aluminum	DC to 10 kHz						
HMMA-1808-VR	8 ±0.125											
HMMA-1818-VR	18 ±0.25											
HMMA-1836-VR	36 ±0.25											
HMMA-2502-VR	2 ±0.063	0.25 dia ±0.006										
HMMA-2508-VR	8 ±0.125											
HMNA-2518-VR-HF	18 ±0.5	0.25 dia ±0.005	0.025 ±0.005		Fiberglass epoxy	DC to 50 kHz						
HMNA-1902-VF	2 ±0.125	0.187 dia ±0.005	0.005 ±0.003			DC to 800 Hz	**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.10% to 30 kG and ±0.15% 30 to 35 kG		±0.13 G/°C	–0.005%/°C	
HMNA-1904-VF	4 ±0.125											
HMNA-1908-VF	8 ±0.125											
HMMA-1802-VF	2 ±0.063	0.180 dia +0.002 -0.004	0.015 ±0.005		Aluminum	DC to 400 Hz						
HMMA-1808-VF	8 ±0.125											
HMMA-1818-VF	18 ±0.25											
HMMA-1836-VF	36 ±0.25											
HMMA-2502-VF	2 ±0.063	0.25 dia ±0.006										
HMMA-2508-VF	8 ±0.125											
HMMA-1808-WL	8 ±0.125	0.180 dia +0.002 -0.004					**HST-3** 35 G, 350 G, 3.5 kG, 35 kG, 350 kG	±1% to 100 kG				
HMMA-2536-WL	36 ±0.25	0.25 dia ±0.006				DC						
for Models 460, 450, and 421												
MMA-0602-TH	2 ±0.125	0.060 dia +0.001 -0.003	0.005 ±0.003	0.020 dia (approx)	Aluminum	DC and 10 Hz to 400 Hz	**HST-2** 300 G, 3 kG, 30 kG	±0.25% to 10 kG	0 °C to +75 °C	±0.13 G/°C	±0.01%/°C	No
MMA-0604-TH	4 ±0.125											
MMA-0608-TH	8 ±0.125											
MMA-0618-TH	18 ±0.25											
MMA-0802-UH	2 ±0.125	0.080 dia ±0.005	0.010 ±0.005			DC		±0.25% to 20 kG				
MMA-0804-UH	4 ±0.125											
MMA-0808-UH	8 ±0.125											
MNA-1902-VH	2 ±0.125	0.187 dia ±0.005	0.005 ±0.003	0.030 dia (approx)	Fiberglass epoxy	DC and 10 Hz to 400 Hz	**HSE-1** 30 G, 300 G, 3 kG, 30 kG	±0.25% to 30 kG		±0.09 G/°C	450: ±0.015%/°C 421: -0.04%/°C	Yes
MNA-1904-VH	4 ±0.125											
MNA-1908-VH	8 ±0.125											
MMA-1802-VH	2 ±0.063	0.180 dia +0.002 -0.004	0.015 ±0.005		Aluminum							
MMA-1808-VH	8 ±0.125											
MMA-1818-VH	18 ±0.25											
MMA-1836-VH	36 ±0.25											
MMA-2502-VH	2 ±0.063	0.25 dia ±0.006										
MMA-2508-VH	8 ±0.125											
MNA-1902-VG	2 ±0.125	0.187 dia ±0.005	0.005 ±0.003		Fiberglass epoxy		**HST-2** 300 G, 3 kG, 30 kG	±0.15% to 30 kG		±0.13 G/°C	-0.005%/°C	No
MNA-1904-VG	4 ±0.125											
MNA-1908-VG	8 ±0.125											
MMA-1802-VG	2 ±0.063	0.180 dia +0.002 -0.004	0.015 ±0.005		Aluminum							
MMA-1808-VG	8 ±0.125											
MMA-1818-VG	18 ±0.25											
MMA-1836-VG	36 ±0.25											
MMA-2502-VG	2 ±0.063	0.25 dia ±0.006										
MMA-2508-VG	8 ±0.125											
MMA-1808-WL	8 ±0.125	0.180 dia +0.002 -0.004					**HST-1** 300 G, 3 kG, 30 kG, 300 kG	±1% to 100 kG				
MMA-2536-WL	36 ±0.25	0.25 dia ±0.006				DC						

Flexible Axial Probes



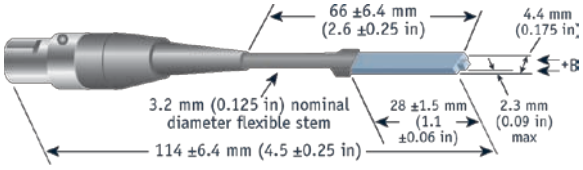
	L (in)	D (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
for Models 475 and 455												
HMFA-1815-VR	15 ±0.5	0.180 +0.002 -0.004	0.015 ±0.005	0.030 dia (approx)	Flexible plastic tubing and aluminum	DC to 10 kHz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG; ±0.25% 30 to 35 kG	0 °C to +75 °C	±0.09 G/°C	±0.015%/°C	Yes
for Models 460, 450, and 421												
MFA-1815-VH	15 ±0.5	0.180 +0.002 -0.004	0.015 ±0.005	0.030 dia (approx)	Flexible plastic tubing and aluminum	DC and 10 Hz to 400 Hz	**HSE-1** 30 G, 300 G, 3 kG, 30 kG	±0.25% to 30 kG	0 °C to +75 °C	±0.09 G/°C	450: ±0.015%/°C 421: -0.04%/°C	Yes

Cryogenic Axial Probes



	L (in)	D (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp error (approx) calibration		Contains temp sensor
for Models 475 and 455											300 K	ref	
HMCA-2560-WN	60 ±0.50	0.25 dia ±0.006	0.025 ±0.005	0.030 dia (approx)	Stainless steel	DC	**HST-3** 35 G, 350 G, 3.5 kG, 35 kG, 350 kG	±2% to 100 kG	1.5 K to 350 K	±0.13 G/°C	200 K 100 K 80 K	+0.05% -0.04% -0.09%	No
for Models 460, 450, and 421											20 K	-0.40%	
MCA-2560-WN	60 ±0.50	0.25 dia ±0.006	0.025 ±0.005	0.030 dia (approx)	Stainless steel	DC	**HST-1** 300 G, 3 kG, 30 kG, 300 kG	±2% to 100 kG	1.5 K to 350 K	±0.13 G/°C	4 K 1.5 K	-0.70% -1.05%	No

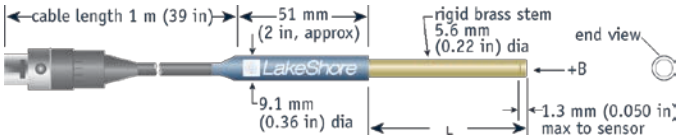
Axial Probes for Model 410 Gaussmeter



	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Accuracy (% rdg)
MSA-410	0.005 × 0.005	Flexible plastic tubing	DC to 10 kHz	200 G, 2 kG, 20 kG	2%

Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
-10 °C to +75 °C	0.1 G/°C	-0.06%/°C	No

Brass Stem Axial Probes for Model 410 Gaussmeter

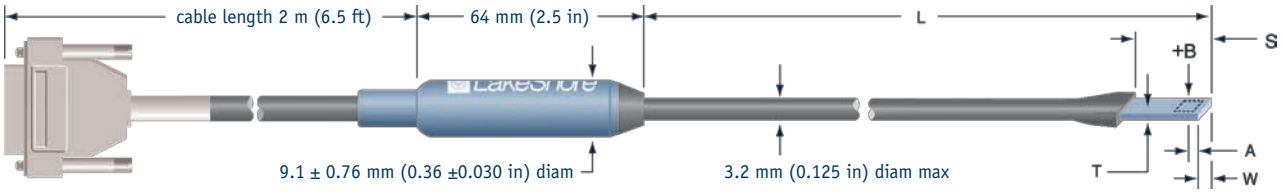


	L (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
MSA-2202-410	2 ±0.125	0.005 × 0.005	Brass	DC	200 G, 2 kG, 20 kG	2%	-10 °C to +75 °C	0.1 G/°C	-0.06%/°C	No
MSA-2204-410	4 ±0.125									

Transverse Probes

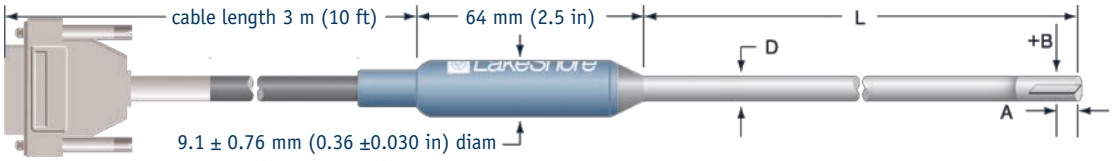
	L (in)	T (in)	W (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
for Models 475 and 455													
HMMT-6J02-VR	2 ±0.125	0.061 max	0.180 ±0.005	0.150 ±0.050	0.040 dia (approx)	Aluminum	DC to 800 Hz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG; ±0.25% 30 to 35 kG	0 °C to +75 °C	±0.09 G/°C	±0.015%/°C	Yes
HMMT-6J04-VR	4 ±0.125												
HMMT-6J08-VR	8 ±0.125												
HMMT-6J18-VR	18 ±0.25												
HMNT-4E02-VR	2 ±0.125	0.045 max	0.150 ±0.005			Fiberglass epoxy	DC to 20 kHz						
HMNT-4E04-VR	4 ±0.125												
HMMT-6J02-VF	2 ±0.125	0.061 max	0.180 ±0.005			Aluminum	DC to 400 Hz	**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.10% to 30 kG; ±0.15% 30 to 35 kG		±0.13 G/°C	–0.005%/°C	
HMMT-6J04-VF	4 ±0.125												
HMMT-6J08-VF	8 ±0.125												
HMMT-6J18-VF	18 ±0.25												
HMNT-4E02-VF	2 ±0.125	0.045 max	0.150 ±0.005			Fiberglass epoxy	DC to 800 Hz						
HMNT-4E04-VF	4 ±0.125												
for Models 460, 450, and 421													
MMT-6J02-VH	2 ±0.125	0.061 max	0.180 ±0.005	0.150 ±0.050	0.040 dia (approx)	Aluminum	DC and 10 Hz to 100 Hz	**HSE-1** 30 G, 300 G, 3 kG, 30 kG	±0.25% to 30 kG	0 °C to +75 °C	±0.09 G/°C	450/460: ±0.015%/°C 421: -0.04%/°C	Yes
MMT-6J04-VH	4 ±0.125												
MMT-6J08-VH	8 ±0.125												
MMT-6J18-VH	18 ±0.25												
MNT-4E02-VH	2 ±0.125	0.045 max	0.150 ±0.005			Fiberglass epoxy	DC and 10 Hz to 400 Hz						
MNT-4E04-VH	4 ±0.125												
MMT-6J02-VG	2 ±0.125	0.061 max	0.180 ±0.005			Aluminum	DC	**HST-2** 300 G, 3 kG, 30 kG	±0.15% to 30 kG		±0.13 G/°C	-0.005%/°C	No
MMT-6J04-VG	4 ±0.125												
MMT-6J08-VG	8 ±0.125												
MMT-6J18-VG	18 ±0.25												
MNT-4E02-VG	2 ±0.125	0.045 max	0.150 ±0.005			Fiberglass epoxy	DC and 10 Hz to 400 Hz						
MNT-4E04-VG	4 ±0.125												

Flexible Transverse Probes



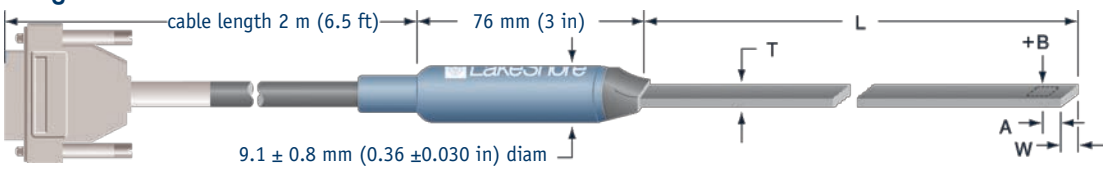
	W (in)	T (in)	A (in)	L (in)	S (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
for Models 475 and 455														
HMFT-3E03-VR	0.135 max	0.025 max	0.125 ±0.005	3 +0.5 -0.125	0.375	0.040 dia (approx)	Flexible plastic tubing	DC to 20 kHz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG; ±0.25% 30 to 35 kG	0 °C to +75 °C	±0.09 G/°C	±0.015%/°C	Yes
HMFT-3E03-VF								DC to 800 Hz	**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.10% to 30 kG; ±0.15% 30 to 35 kG		±0.13 G/°C	–0.005%/°C	
HMFT-2903-VJ	0.085 max	0.020 max	0.065 ±0.005			0.030 dia (approx)		DC to 20 kHz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.50% to 35 kG		±0.09 G/°C	±0.015%/°C	
HMFT-2903-VH								DC to 800 Hz	**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.25% to 35 kG		±0.13 G/°C	–0.005%/°C	
HMFT-4F15-VR	0.150 ±0.005	0.045 max	0.150 ±0.050	15 ±0.5	0.75	0.040 dia (approx)	Flexible plastic tubing and epoxy fiberglass	DC to 20 kHz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG; ±0.25% 30 to 35 kG		±0.09 G/°C	±0.015%/°C	
HMFT-4F15-VR-HF								DC to 50 kHz						
HMFT-4F15-VF								DC to 800 Hz	**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.10% to 30 kG; ±0.15% 30 to 35 kG		±0.13 G/°C	–0.005%/°C	
for Models 460, 450, and 421														
MFT-3E03-VH	0.135 max	0.025 max	0.125 ±0.005	3 +0.5 -0.125	0.375	0.040 dia (approx)	Flexible plastic tubing	DC and 10 Hz to 400 Hz	**HSE-1** 30 G, 300 G, 3 kG, 30 kG	±0.25% to 30 kG	0 °C to +75 °C	±0.09 G/°C	450/460: ±0.015%/°C 421: -0.04%/°C	Yes
MFT-3E03-VG									**HST-2** 300 G, 3 kG, 30 kG	±0.15% to 30 kG		±0.13 G/°C	-0.005%/°C	No
MFT-2903-VJ	0.085 max	0.020 max	0.065 ±0.005			0.030 dia (approx)			**HSE-1** 30 G, 300 G, 3 kG, 30 kG	±0.50% to 30 kG		±0.09 G/°C	450/460: ±0.015%/°C 421: -0.04%/°C	Yes
MFT-2903-VH									**HST-2** 300 G, 3 kG, 30 kG	±0.25% to 30 kG		±0.13 G/°C	-0.005%/°C	No
MFT-4F15-VH	0.150 ±0.005	0.045 max	0.150 ±0.050	15 ±0.5	0.75	0.040 dia (approx)	Flexible plastic tubing and epoxy fiberglass		**HSE-1** 30 G, 300 G, 3 kG, 30 kG			±0.09 G/°C	450/460: ±0.015%/°C 421: -0.04%/°C	Yes
MFT-4F15-VG									**HST-2** 300 G, 3 kG, 30 kG	±0.15% to 30 kG		±0.13 G/°C	-0.005%/°C	No

Cryogenic Transverse Probes



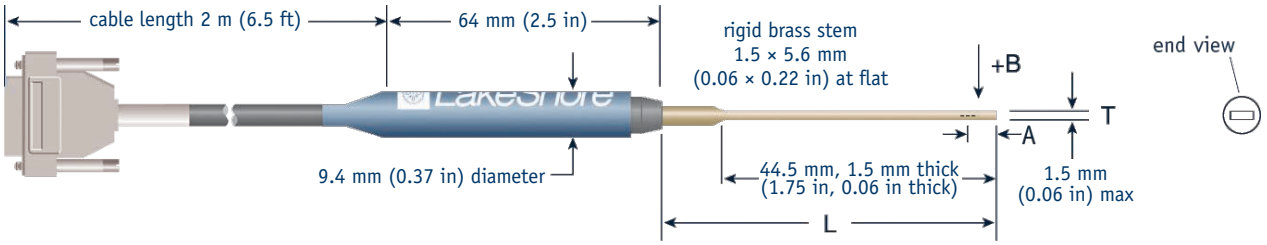
	L (in)	D (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp error (approx) calibration		Contains temp sensor
for Models 475 and 455											300 K	ref	
HMCT-3160-WN	61 ±1	0.25 dia ±0.010	0.210 ±0.050	0.040 dia (approx)	Stainless steel	DC to 800 Hz	**HST-3** 35 G, 350 G, 3.5 kG, 35 kG, 350 kG	±2% to 100 kG	1.5 K to 350 K	±0.13 G/°C	200 K	+0.05%	No
											100 K	-0.04%	
											80 K	-0.09%	
for Models 460, 450, and 421											20 K	-0.40%	
MCT-3160-WN	61 ±1	0.25 dia ±0.010	0.210 ±0.050	0.040 dia (approx)	Stainless steel	DC and 10 Hz to 400 Hz	**HST-1** 300 G, 3 kG, 30 kG, 300 kG	±2% to 100 kG	1.5 K to 350 K	±0.13 G/°C	4 K	-0.70%	No
											1.5 K	-1.05%	

Tangential Probes



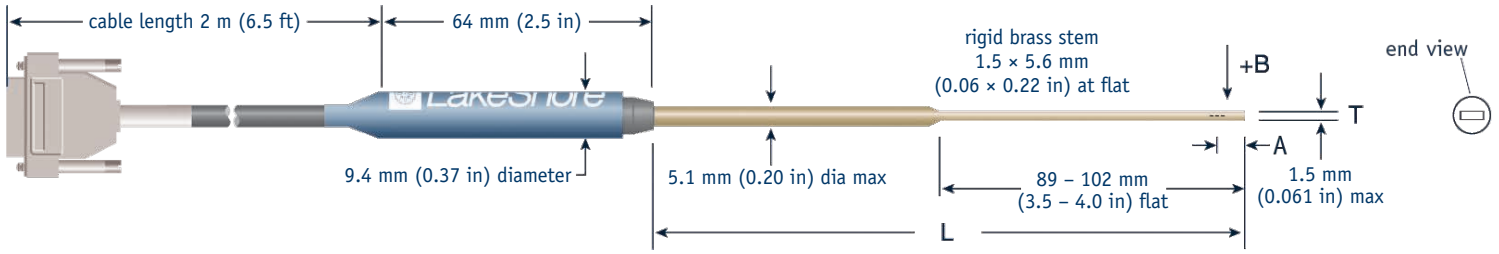
	L (in)	T (in)	W (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
for Models 475 and 455													
HMNTAN-DQ02-TH	1.5 ±0.060	0.11 (max)	0.26 (max)	0.030 ±0.005	0.020 dia (approx)	Plastic	DC to 400 Hz	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	0.25% to 20 kG	0 °C to +75 °C	±0.1 G/°C	-0.02%/°C	Yes
for Models 460, 450, and 421													
MNTAN-DQ02-TH	1.5 ±0.060	0.11 (max)	0.26 (max)	0.030 ±0.005	0.020 dia (approx)	Plastic	DC and 10 Hz to 400 Hz	**HSE-1** 30 G, 300 G, 3 kG, 30 kG	0.25% to 20 kG	0 °C to +75 °C	±0.1 G/°C	-0.05%/°C	No

Brass Stem Transverse Probes (Short Stem)



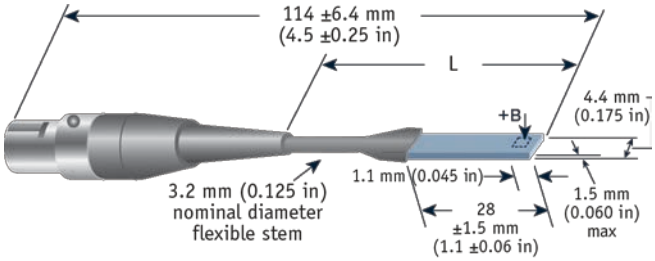
	L (in)	T (in)	Width (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
for Models 475 and 455													
HMMTB-6J02-VR	2 ±0.125	0.061 max	0.22	0.150 ±0.050	0.040 dia (approx)	Brass	DC	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG and ±0.25% 30 to 35 kG	0 °C to +75 °C	±0.09 G/°C	±0.015%/°C	Yes
HMMTB-6J02-VF								**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.10% to 30 kG and ±0.15% 30 to 35 kG		±0.13 G/°C	-0.005%/°C	
for Models 460, 450, and 421													
MMTB-6J02-VH	2 ±0.125	0.061 max	0.22	0.150 ±0.050	0.040 dia	Brass	DC	**HSE-1** 30 G, 300 G, 3 kG, 30 kG	±0.25% to 30 kG	0 °C to +75 °C	±0.09 G/°C	450/460: ±0.015%/°C 421:-0.04%/°C	Yes
MMTB-6J02-VG	2 ±0.125							**HST-2** 300 G, 3 kG, 30 kG	±0.15% to 30 kG		±0.13 G/°C	-0.005%/°C	No

Brass Stem Transverse Probes (Long Stem)



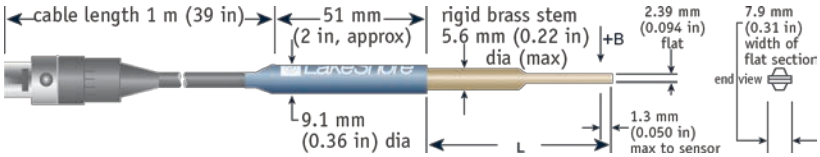
	L (in)	T (in)	Width (in)	A (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
for Models 475 and 455													
HMMTB-6J04-VR	4 ±0.125	0.061 max	0.22	0.150 ±0.050	0.040 dia (approx)	Brass	DC	**HSE** 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG	±0.20% to 30 kG and ±0.25% 30 to 35 kG	0 °C to +75 °C	±0.09 G/°C	±0.015%/°C	Yes
HMMTB-6J08-VR	8 ±0.125												
HMMTB-6J04-VF	4 ±0.125							**HST-4** 35 G, 350 G, 3.5 kG, 35 kG	±0.10% to 30 kG and ±0.15% 30 to 35 kG		±0.13 G/°C	-0.005%/°C	
HMMTB-6J08-VF	8 ±0.125												
for Models 460, 450, and 421													
MMTB-6J04-VH	4 ±0.125	0.061 max	0.22	0.150 ±0.050	0.040 dia	Brass	DC	**HSE-1** 30 G, 300 G, 3 kG, 30 kG	±0.25% to 30 kG	0 °C to +75 °C	±0.09 G/°C	450/460: ±0.015%/°C 421:-0.04%/°C	Yes
MMTB-6J08-VH	8 ±0.125												
MMTB-6J04-VG	4 ±0.125							**HST-2** 300 G, 3 kG, 30 kG	±0.15% to 30 kG		±0.13 G/°C	-0.005%/°C	No
MMTB-6J08-VG	8 ±0.125												

Transverse Probes for Model 410 Gaussmeter



	L (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
MST-410	2.6 ±0.25	0.005 × 0.005	Flexible plastic tubing	DC to 10 kHz	200 G, 2 kG, 20 kG	2%	-10 °C to +75 °C	0.1 G/°C	-0.06%/°C	No

Brass Stem Transverse Probes for Model 410 Gaussmeter

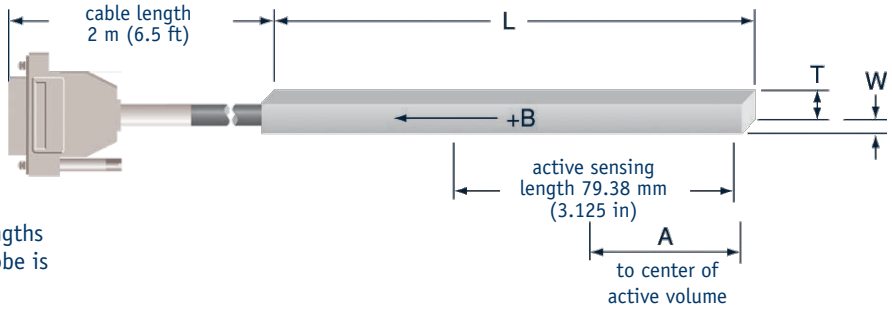


	L (in)	Active area (in)	Stem material	Frequency range	Usable full scale ranges	Accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
MST-9P02-410	2 ±0.125	0.005 × 0.005	Brass	DC	200 G, 2 kG, 20 kG	2%	-10 °C to +75 °C	0.1 G/°C	-0.06%/°C	No
MST-9P04-410	4 ±0.125									

Gamma Probes

Small variations in, or low values of large volume magnetic fields, such as that of the earth or fringe fields around large solenoids, can be measured with these ultra high sensitivity probes. Resolutions of several gammas (10^{-5} G) to tens of gammas are available depending on the mating gaussmeter.

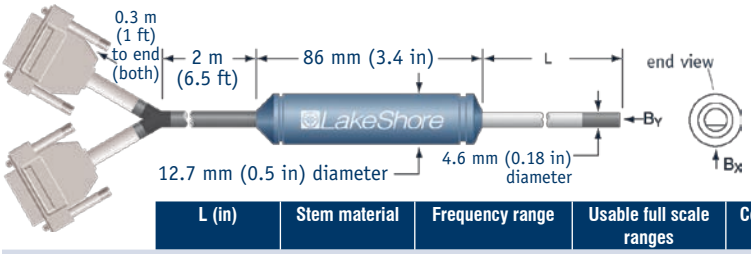
Application is optimum when fields are homogeneous over lengths greater than 1 ft. The active sensing length of the gamma probe is approximately 3.125 in.



For absolute zero, a 4065 zero gauss chamber is required.
The standard 4060 zero gauss chamber is too small for the gamma probe.

	W (in)	T (in)	A (in)	L (in)	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
for Models 475 and 455											
HMLA-5006-HJ	0.25 ±0.03	0.5	2.2	5.7	DC to 400 Hz	**UHS** 35 mG, 350 mG, 3.5 G, 35 G	±0.5% to 2 G	0 °C to +75 °C	1 mG/°C	±0.02%/°C	Yes
for Models 460, 450, and 421											
MLA-5006-HJ	0.25 ±0.03	0.5	2.2	5.7	DC and 10 Hz to 400 Hz	**UHS-1** 300 mG, 3 G, 30 G	±0.5% to 2 G	0 °C to +75 °C	1 mG/°C	450/460: ±0.02%/°C 421:-0.05%/°C	Yes

2-Axis Probes



	L (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
for Model 460 ONLY									
MMY-1802-UH	2 ±0.125	Aluminum	DC and 10 Hz to 400 Hz	**HSE-1** 30 G, 300 G, 3 kG, 30 kG	0.25% to 20 kG; 0.5% from 20 kG to 30 kG	10 °C to 40 °C	±0.09 G/°C	±0.015%/°C	Yes
MMY-1808-UH	8 ±0.125								
MMY-1818-UH	18 ±0.25								
MMY-1836-UH	36 ±0.25								

3-Axis Probes

	L (in)	Stem material	Frequency range	Usable full scale ranges	Corrected accuracy (% rdg at 25 °C)	Operating temp range	Temp coefficient (max) zero	Temp coefficient (max) calibration	Contains temp sensor
for Model 460 ONLY									
MMZ-2502-UH	2.125 ±0.125	Aluminum	DC and 10 Hz to 400 Hz	**HSE-1** 30 G, 300 G, 3 kG, 30 kG	0.25% to 20 kG; 0.5% from 20 kG to 30 kG	10 °C to 40 °C	±0.09 G/°C	±0.015%/°C	Yes
MMZ-2508-UH	8.125 ±0.125								
MMZ-2512-UH	12.125 ±0.125								
MMZ-2518-UH	18.125 ±0.25								
MMZ-2536-UH	36.125 ±0.25								
MMZ-2560-UH	60.375 ±0.5								

The sensors at the ends of the multi-axis probes are quite fragile and susceptible to damage. Lake Shore offers an assortment of brass covers for probe protection during use with DC fields. Consult Lake Shore for model numbers and pricing.

Ordering Information – Axial Probes

Model 475 and 455 Axial Probes

HMMA-0602-TH	Probe, metal axial: 0.06 diameter × 2 in
HMMA-0604-TH	Probe, metal axial: 0.06 diameter × 4 in
HMMA-0608-TH	Probe, metal axial: 0.06 diameter × 8 in
HMMA-0618-TH	Probe, metal axial: 0.06 diameter × 18 in
HMMA-0802-UH	Probe, metal axial: 0.08 diameter × 2 in
HMMA-0804-UH	Probe, metal axial: 0.08 diameter × 4 in
HMMA-0808-UH	Probe, metal axial: 0.08 diameter × 8 in
HMMA-1802-VF	Probe, metal axial: 0.180 diameter × 2 in
HMMA-1808-VF	Probe, metal axial: 0.180 diameter × 8 in
HMMA-1818-VF	Probe, metal axial: 0.180 diameter × 18 in
HMMA-1836-VF	Probe, metal axial: 0.180 diameter × 36 in
HMMA-1802-VR	Probe, metal axial: 0.180 diameter × 2 in
HMMA-1808-VR	Probe, metal axial: 0.180 diameter × 8 in
HMMA-1818-VR	Probe, metal axial: 0.180 diameter × 18 in
HMMA-1836-VR	Probe, metal axial: 0.180 diameter × 36 in
HMMA-1808-WL	Probe, metal axial: 0.180 diameter × 8 in
HMMA-2502-VF	Probe, metal axial: 0.25 diameter × 2 in
HMMA-2508-VF	Probe, metal axial: 0.25 diameter × 8 in
HMMA-2502-VR	Probe, metal axial: 0.25 diameter × 2 in
HMMA-2508-VR	Probe, metal axial: 0.25 diameter × 8 in
HMMA-2536-WL	Probe, metal axial: 0.25 diameter × 36 in
HMNA-1902-VF	Non-metallic axial: 0.187 diameter × 2 in
HMNA-1904-VF	Non-metallic axial: 0.187 diameter × 4 in
HMNA-1908-VF	Non-metallic axial: 0.187 diameter × 8 in
HMNA-1902-VR	Non-metallic axial: 0.187 diameter × 2 in
HMNA-1904-VR	Non-metallic axial: 0.187 diameter × 4 in
HMNA-1908-VR	Non-metallic axial: 0.187 diameter × 8 in
HMNA-2518-VR-HF	Non-metallic axial: 0.25 diameter × 18 in

Model 475 and 455 Flexible Axial Probes

HMFA-1815-VR	Probe, flexible axial, 0.180 diameter × 15 in

Model 475 and 455 Cryogenic Axial Probes

HMCA-2560-WN	Probe, cryogenic axial, 0.25 diameter × 60 in

Model 460, 450, and 421 Axial Probes

MMA-0602-TH	Probe, metal axial: 0.06 diameter × 2 in
MMA-0604-TH	Probe, metal axial: 0.06 diameter × 4 in
MMA-0608-TH	Probe, metal axial: 0.06 diameter × 8 in
MMA-0618-TH	Probe, metal axial: 0.06 diameter × 18 in
MMA-0802-UH	Probe, metal axial: 0.08 diameter × 2 in
MMA-0804-UH	Probe, metal axial: 0.08 diameter × 4 in
MMA-0808-UH	Probe, metal axial: 0.08 diameter × 8 in
MMA-1802-VG	Probe, metal axial: 0.180 diameter × 2 in
MMA-1808-VG	Probe, metal axial: 0.180 diameter × 8 in
MMA-1818-VG	Probe, metal axial: 0.180 diameter × 18 in
MMA-1836-VG	Probe, metal axial: 0.180 diameter × 36 in
MMA-1802-VH	Probe, metal axial: 0.180 diameter × 2 in
MMA-1808-VH	Probe, metal axial: 0.180 diameter × 8 in
MMA-1818-VH	Probe, metal axial: 0.180 diameter × 18 in
MMA-1836-VH	Probe, metal axial: 0.180 diameter × 36 in
MMA-1808-WL	Probe, metal axial: 0.180 diameter × 8 in
MMA-2502-VG	Probe, metal axial: 0.25 diameter × 2 in
MMA-2508-VG	Probe, metal axial: 0.25 diameter × 8 in
MMA-2502-VH	Probe, metal axial: 0.25 diameter × 2 in
MMA-2508-VH	Probe, metal axial: 0.25 diameter × 8 in
MMA-2536-WL	Probe, metal axial: 0.25 diameter × 36 in
MNA-1902-VH	Non-metallic axial: 0.187 diameter × 2 in
MNA-1904-VH	Non-metallic axial: 0.187 diameter × 4 in
MNA-1908-VH	Non-metallic axial: 0.187 diameter × 8 in
MNA-1902-VG	Non-metallic axial: 0.187 diameter × 2 in
MNA-1904-VG	Non-metallic axial: 0.187 diameter × 4 in
MNA-1908-VG	Non-metallic axial: 0.187 diameter × 8 in

Model 460, 450, and 421 Flexible Axial Probes

MFA-1815-VH	Probe, flexible axial, 0.180 diameter × 15 in

Model 460, 450, and 421 Cryogenic Axial Probes

MCA-2560-WN	Probe, cryogenic axial, 0.25 diameter × 60 in

Model 410 Axial Probes

MSA-410	Probe, axial for the 410

Model 410 Brass Stem Axial Probes

MSA-2202-410	Probe, brass axial for the 410, 2 in
MSA-2204-410	Probe, brass axial for the 410, 4 in

All specifications are subject to change without notice

Ordering Information — Transverse Probes

Model 475 and 455 Transverse Probes

HMNT-4E02-VF	Probe, non-metallic transverse, 0.04 × 0.14 × 2 in
HMNT-4E04-VF	Probe, non-metallic transverse, 0.04 × 0.14 × 4 in
HMNT-4E02-VR	Probe, non-metallic transverse, 0.04 × 0.14 × 2 in
HMNT-4E04-VR	Probe, non-metallic transverse, 0.04 × 0.14 × 4 in
HMMT-6J02-VF	Probe, metal transverse, 0.06 × 0.18 × 2 in
HMMT-6J04-VF	Probe, metal transverse, 0.06 × 0.18 × 4 in
HMMT-6J08-VF	Probe, metal transverse, 0.06 × 0.18 × 8 in
HMMT-6J18-VF	Probe, metal transverse, 0.06 × 0.18 × 18 in
HMMT-6J02-VR	Probe, metal transverse, 0.06 × 0.18 × 2 in
HMMT-6J04-VR	Probe, metal transverse, 0.06 × 0.18 × 4 in
HMMT-6J08-VR	Probe, metal transverse, 0.06 × 0.18 × 8 in
HMMT-6J18-VR	Probe, metal transverse, 0.06 × 0.18 × 18 in

Model 475 and 455 Flexible Transverse Probes

HMFT-3E03-VF	Probe, flexible transverse, 0.03 × 0.14 × 3 in
HMFT-3E03-VR	Probe, flexible transverse, 0.03 × 0.14 × 3 in
HMFT-4F15-VF	Probe, flexible transverse, 0.04 × 0.15 × 15 in
HMFT-4F15-VR	Probe, flexible transverse, 0.05 × 0.15 × 15 in
HMFT-4F15-VR-HF	Probe, flexible transverse, 0.05 × 0.15 × 15 in
HMFT-2903-VH	Probe, flexible transverse, 0.02 × 0.09 × 3 in
HMFT-2903-VJ	Probe, flexible transverse, 0.02 × 0.09 × 3 in

Model 475 and 455 Cryogenic Transverse Probes

HMCT-3160-WN	Probe, cryogenic transverse, 0.25 dia × 60 in

Model 475 and 455 Tangential Probes

HMNTAN-DQ02-TH	Probe, tangential, 0.125 × 0.38 × 1.5 in

Model 475 and 455 Brass Stem Probes

HMMTB-6J02-VF	Probe, brass stem, 0.06 × 0.22 × 2 in
HMMTB-6J04-VF	Probe, brass stem, 0.06 × 0.22 × 4 in
HMMTB-6J08-VF	Probe, brass stem, 0.06 × 0.22 × 8 in
HMMTB-6J02-VR	Probe, brass stem, 0.06 × 0.22 × 2 in
HMMTB-6J04-VR	Probe, brass stem, 0.06 × 0.22 × 4 in
HMMTB-6J08-VR	Probe, brass stem, 0.06 × 0.22 × 8 in

Model 460, 450, and 421 Transverse Probes

MNT-4E02-VG	Probe, non-metallic transverse, 0.04 × 0.14 × 2 in
MNT-4E04-VG	Probe, non-metallic transverse, 0.04 × 0.14 × 4 in
MNT-4E02-VH	Probe, non-metallic transverse, 0.04 × 0.14 × 2 in
MNT-4E04-VH	Probe, non-metallic transverse, 0.04 × 0.14 × 4 in
MMT-6J02-VG	Probe, metal transverse, 0.06 × 0.18 × 2 in
MMT-6J04-VG	Probe, metal transverse, 0.06 × 0.18 × 4 in
MMT-6J08-VG	Probe, metal transverse, 0.06 × 0.18 × 8 in
MMT-6J18-VG	Probe, metal transverse, 0.06 × 0.18 × 18 in
MMT-6J02-VH	Probe, metal transverse, 0.06 × 0.18 × 2 in
MMT-6J04-VH	Probe, metal transverse, 0.06 × 0.18 × 4 in
MMT-6J08-VH	Probe, metal transverse, 0.06 × 0.18 × 8 in
MMT-6J18-VH	Probe, metal transverse, 0.06 × 0.18 × 18 in

Model 460, 450, and 421 Flexible Transverse Probes

MFT-3E03-VG	Probe, flexible transverse, 0.03 × 0.14 × 3 in
MFT-3E03-VH	Probe, flexible transverse, 0.03 × 0.14 × 3 in
MFT-4F15-VG	Probe, flexible transverse, 0.04 × 0.15 × 15 in
MFT-4F15-VH	Probe, flexible transverse, 0.05 × 0.15 × 15 in
MFT-2903-VH	Probe, flexible transverse, 0.02 × 0.09 × 3 in
MFT-2903-VJ	Probe, flexible transverse, 0.02 × 0.09 × 3 in

Model 460, 450, and 421 Cryogenic Transverse Probes

MCT-3160-WN	Probe, cryogenic transverse, 0.25 dia × 60 in

Model 460, 450, and 421 Tangential Probes

MNTAN-DQ02-TH	Probe, tangential, 0.125 × 0.38 × 1.5 in

Model 460, 450, and 421 Brass Stem Probes

MMTB-6J02-VG	Probe, brass stem, 0.06 × 0.22 × 2 in
MMTB-6J04-VG	Probe, brass stem, 0.06 × 0.22 × 4 in
MMTB-6J08-VG	Probe, brass stem, 0.06 × 0.22 × 8 in
MMTB-6J02-VH	Probe, brass stem, 0.06 × 0.22 × 2 in
MMTB-6J04-VH	Probe, brass stem, 0.06 × 0.22 × 4 in
MMTB-6J08-VH	Probe, brass stem, 0.06 × 0.22 × 8 in

Model 410 Transverse Probes

MST-410	Probe, transverse for the 410
MST-9P02-410	Probe, brass transverse for the 410, 2 in
MST-9P04-410	Probe, brass transverse for the 410, 4 in

Ordering Information — Gamma, 2- and 3-Axis Probes

Model 475 and 455 Gamma Probes

HMLA-5006-HJ	Gamma probe, non-metallic axial, 0.25 × 0.5 × 6 in

Model 460, 450, and 421 Gamma Probes

MLA-5006-HJ	Gamma probe, non-metallic axial, 0.25 × 0.5 × 6 in

Model 460 2-Axis Probes

MMY-1802-UH	2-axis probe: 2 in long
MMY-1808-UH	2-axis probe: 8 in long
MMY-1818-UH	2-axis probe: 18 in long
MMY-1836-UH	2-axis probe: 36 in long

Model 460 3-Axis Probes

MMZ-2502-UH	3-axis probe: 2 in long
MMZ-2508-UH	3-axis probe: 8 in long
MMZ-2512-UH	3-axis probe: 12 in long
MMZ-2518-UH	3-axis probe: 18 in long
MMZ-2536-UH	3-axis probe: 36 in long
MMZ-2560-UH	3-axis probe: 60 in long

Ordering Information — Data and Certificates

New Product Calibration Data and Certificates

CAL-N1X1-DATA	Calibration data for new Model 410 probe
CAL-N1X-DATA	Calibration data for new 1-axis Hall probe
CAL-N2X-DATA	Calibration data for new 2-axis Hall probe
CAL-N3X-DATA	Calibration data for new 3-axis Hall probe

Recalibration Data and Certificates

CAL-1X1-CERT	1-axis probe for 410 recalibrated with certificate
CAL-1X1-DATA	1-axis probe for 410 recalibrated with certificate and data
CAL-1X5-CERT	1-axis probe for 460/450/421 recalibrated with certificate
CAL-1X5-DATA	1-axis probe for 460/450/421 recalibrated with certificate and data
CAL-1X7-CERT	1-axis probe for 475/455 recalibrated with certificate
CAL-1X7-DATA	1-axis probe for 475/455 recalibrated with certificate and data
CAL-2X6-CERT	2-axis probe for 460 recalibrated with certificate
CAL-2X6-DATA	2-axis probe for 460 recalibrated with certificate and data
CAL-3X6-CERT	3-axis probe for 460 recalibrated with certificate
CAL-3X6-DATA	3-axis probe for 460 recalibrated with certificate and data
CAL-G5-CERT	Gamma probe for 460/450/421 recalibrated with certificate
CAL-G5-DATA	Gamma probe for 460/450/421 recalibrated with certificate and data
CAL-G7-CERT	Gamma probe for 475/455 recalibrated with certificate
CAL-G7-DATA	Gamma probe for 475/455 recalibrated with certificate and data

All specifications are subject to change without notice

Extension Cables

To maintain probe accuracy, probes and extension cables for Models 460, 450, and 421 must be calibrated together at Lake Shore. When ordering an extension cable and more than one probe, it is necessary to specify with which probe the cable will be used. It should be noted that probes will exhibit their full accuracy specifications when used without an extension cable. Model 460 2- and 3-axis probes require 2- and 3-extension cables, respectively. Extension cables for Models 475 and 455 are field programmable, but can be ordered factory-calibrated.

Probe Extension Cables for Model 460, 450, and 421 Gaussmeters

	Length
MPEC-10	3 m (10 ft)
MPEC-25	7.6 m (25 ft)
MPEC-50	15 m (50 ft)
MPEC-100	30 m (100 ft)

Probe Extension Cables for Model 475 and 455 Gaussmeters

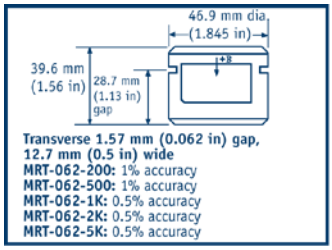
	Length
HMPEC-10	3 m (10 ft) calibrated
HMPEC-10-U	3 m (10 ft) uncalibrated
HMPEC-25	7.6 m (25 ft) calibrated
HMPEC-25-U	7.6 m (25 ft) uncalibrated
HMPEC-50	15 m (50 ft) calibrated
HMPEC-50-U	15 m (50 ft) uncalibrated
HMPEC-100	30 m (100 ft) calibrated
HMPEC-100-U	30 m (100 ft) uncalibrated

Hall Probe Stands

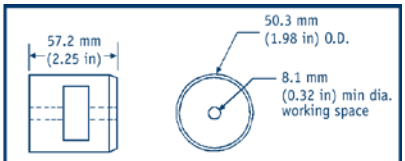
These moveable probe stands consist of a 30 mm (1.2 in) square post mounted on a 180 mm × 130 mm × 22.5 mm (7.1 × 5.1 × 0.9 in) thick base plate. A probe holder is integrated into the stand. The holder can be moved up or down and fixed at any angle and location along the post. Two standard models are available. Consult Lake Shore for other post heights.

Reference Magnets

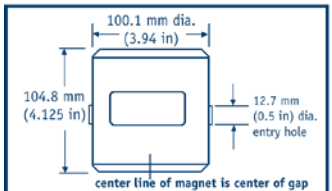
High quality reference magnets are available in transverse (flat) and axial (round) configurations—also see Helmholtz coil low field references on page 45.



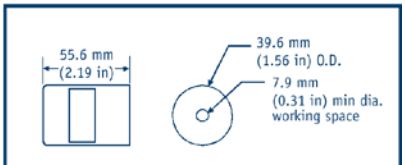
Transverse 1.57 mm (0.062 in) gap, 12.7 mm (0.5 in) wide
MRT-062-200: 1% accuracy
MRT-062-500: 1% accuracy
MRT-062-1K: 0.5% accuracy
MRT-062-2K: 0.5% accuracy
MRT-062-5K: 0.5% accuracy



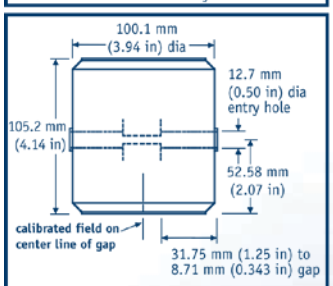
Axial 7.92 mm (0.312 in) diameter working space
MRA-312-2K: 1% accuracy
MRA-312-1K: 1% accuracy



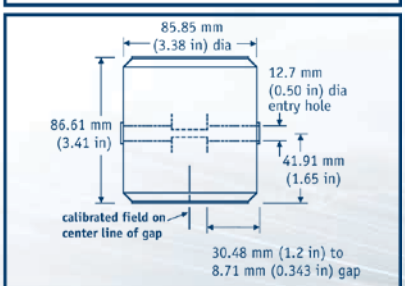
Transverse 1.57 mm (0.062 in) gap, 12.7 mm (0.5 in) wide
MRT-062-10K: 0.5% accuracy



Axial 7.92 mm (0.312 in) diameter working space
MRA-312-100: 1% accuracy
MRA-312-200: 1% accuracy
MRA-312-500: 1% accuracy



MRT-343-1K: 1% accuracy
MRT-343-2K: 1% accuracy



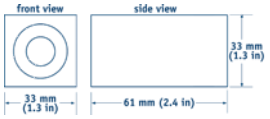
MRT-343-50: 1% accuracy
MRT-343-100: 1% accuracy
MRT-343-200: 1% accuracy

Zero Gauss Chambers

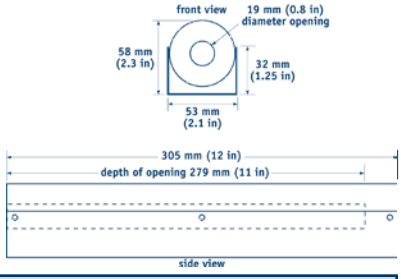
To obtain a null field reference a zero gauss chamber must be used to shield the probe sensing area from external field. The 4065 should be ordered with the gamma probe and can be used with the other probes.

	Size	Bore
4060 – Standard	33 mm × 33 mm × 61 mm (1.3 in × 1.3 in × 2.4 in)	13 mm diameter × 51 mm (0.5 in diameter × 2 in)
4065 – Large (for gamma probe)	58 mm × 53 mm × 305 mm (2.3 in × 2.1 in × 12 in)	19 mm diameter × 279 mm (0.75 in diameter × 11 in)

4060 Zero Gauss Chamber



4065 Zero Gauss Chamber



Ordering Information

Part number	Description
Extension cables	
HMPEC-10	475/455 probe extension cable with EEPROM (10 ft), calibrated
HMPEC-10-U	475/455 probe extension cable with EEPROM (10 ft), uncalibrated
HMPEC-25	475/455 probe extension cable with EEPROM (25 ft), calibrated
HMPEC-25-U	475/455 probe extension cable with EEPROM (25 ft), uncalibrated
HMPEC-50	475/455 probe extension cable with EEPROM (50 ft), calibrated
HMPEC-50-U	475/455 probe extension cable with EEPROM (50 ft), uncalibrated
HMPEC-100	475/455 probe extension cable with EEPROM (100 ft), calibrated
HMPEC-100-U	475/455 probe extension cable with EEPROM (100 ft), uncalibrated
MPEC-10	460/450/421 calibrated probe extension cable (10 ft)
MPEC-25	460/450/421 calibrated probe extension cable (25 ft)
MPEC-50	460/450/421 calibrated probe extension cable (50 ft)
MPEC-100	460/450/421 calibrated probe extension cable (100 ft)
MPEC-410-10	410 universal probe extension cable (10 ft)
MPEC-410-3	410 universal probe extension cable (3 ft)
Hall probe stands	
4030-12	Hall probe stand, 12 in post, accepts 3/8 in dia. Hall probe handle
4030-24	Hall probe stand, 24 in post, accepts 3/8 in dia. Hall probe handle
Zero gauss chambers	
4060	Zero gauss chamber
4065	Zero gauss chamber for gamma probe
Reference magnets	
MRA-312-100	Axial reference magnet: 0.312 in inside diameter, 100 G, 1%
MRA-312-200	Axial reference magnet: 0.312 in inside diameter, 200 G, 1%
MRA-312-300	Axial reference magnet: 0.312 in inside diameter, 300 G, 1%
MRA-312-500	Axial reference magnet: 0.312 in inside diameter, 500 G, 1%
MRA-312-1K	Axial reference magnet: 0.312 in inside diameter, 1 kG, 1%
MRA-312-2K	Axial reference magnet: 0.312 in inside diameter, 2 kG, 1%
MRT-062-200	Transverse reference magnet: 0.062 in gap, 200 G, 1%
MRT-062-500	Transverse reference magnet: 0.062 in gap, 500 G, 1%
MRT-062-1K	Transverse reference magnet: 0.062 in gap, 1 kG, 0.5%
MRT-062-2K	Transverse reference magnet: 0.062 in gap, 2 kG, 0.5%
MRT-062-5K	Transverse reference magnet: 0.062 in gap, 5 kG, 0.5%
MRT-062-10K	Transverse reference magnet: 0.062 in gap, 10 kG, 0.5%
MRT-343-50	Transverse reference magnet: 0.343 in gap, 50 G, 1%
MRT-343-100	Transverse reference magnet: 0.343 in gap, 100 G, 1%
MRT-343-200	Transverse reference magnet: 0.343 in gap, 200 G, 1%
MRT-343-1K	Transverse reference magnet: 0.343 in gap, 1 kG, 1%
MRT-343-2K	Transverse reference magnet: 0.343 in gap, 2 kG, 1%

All specifications are subject to change without notice

Magnetic Field Sensors (Hall Generators)

Hall Generator Theory

A Hall generator is a solid state sensor which provides an output voltage proportional to magnetic flux density. As implied by its name, this device relies on the Hall effect. The Hall effect is the development of a voltage across a sheet of conductor when current is flowing and the conductor is placed in a magnetic field.

Electrons (the majority carrier most often used in practice) "drift" in the conductor when under the influence of an externally produced electric field. These moving electrons experience a force proportional and perpendicular to the product of their velocity and the magnetic field vector. This force causes the charging of the edges of the conductor, one side positive with respect to the other, resulting in an internally generated transverse electric field which exerts a force on the moving electrons equal and opposite to that caused by the magnetic-field-related Lorentz force. The resultant voltage potential across the width of the conductor is called the Hall voltage and can be measured by attaching two electrical contacts to the sides of the conductor.

The Hall voltage can be given by the expression:

$$V_H = \gamma_B B \sin\theta$$

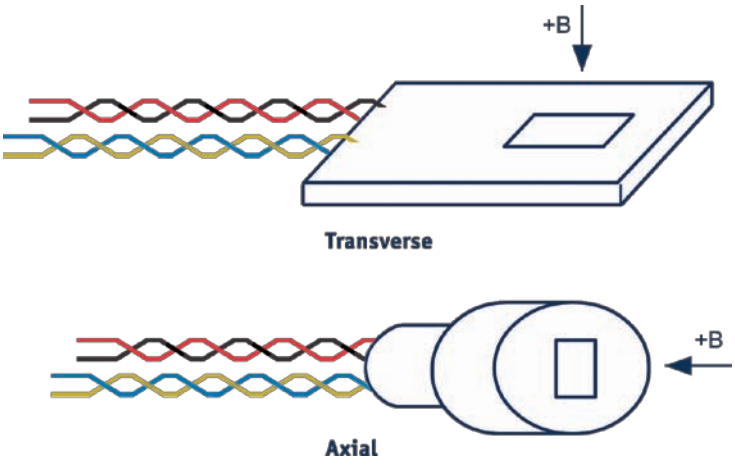
where V_H = Hall voltage (mV)

γ_B = Magnetic sensitivity (mV per kG, at a fixed current)

B = Magnetic field flux density (kG)

θ = Angle between magnetic flux vector and the plane of Hall generator

As can be seen from the above formula, the Hall voltage varies with the angle of the sensed magnetic field, reaching a maximum when the field is perpendicular to the plane of the Hall generator.



Hall generators come in axial and transverse configurations.

Transverse devices are generally thin and rectangular in shape. They are applied successfully in magnetic circuit gaps, surface measurements, and general open field measurements.

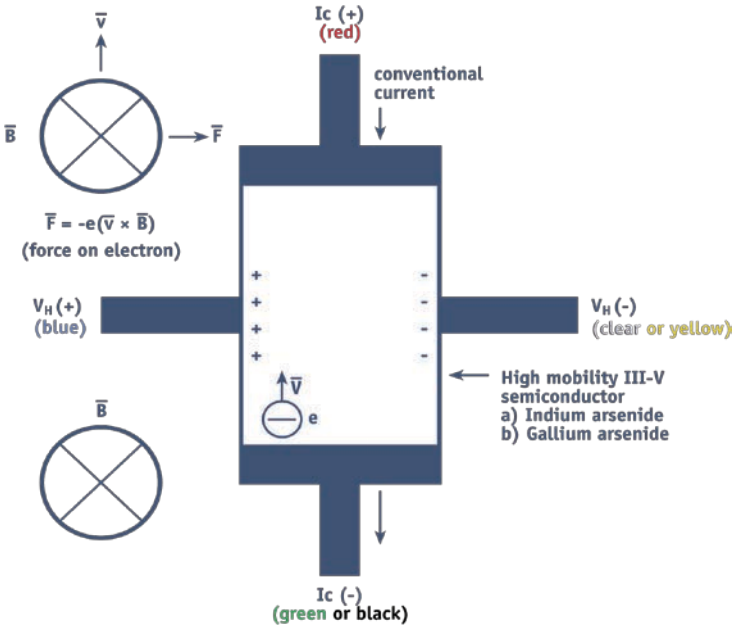
Axial sensors are mostly cylindrical in shape. Their applications include ring magnet center bore measurements, solenoids, surface field detection, and general field sensing. See the individual Hall generator illustrations for physical dimensions.

Active Area

The Hall generator assembly contains the sheet of semiconductor material to which the four contacts are made. This entity is normally called a "Hall plate." The Hall plate is, in its simplest form, a rectangular shape of fixed length, width and thickness. Due to the shorting effect of the current supply contacts, most of the sensitivity to magnetic fields is contained in an area approximated by a circle, centered in the Hall plate, whose diameter is equal to the plate width. Thus, when the active area is given, the circle as described above is the common estimation.

Using a Hall Generator

A Hall generator is a 4-lead device. The control current (I_c) leads are normally attached to a current source such as the Lake Shore Model 120CS. The Model 120CS provides several fixed current values compatible with various Hall generators.

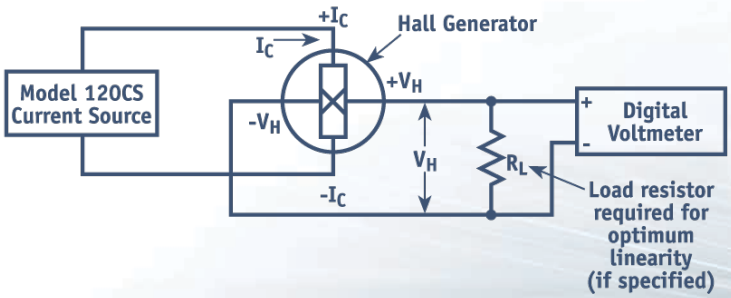


Caution: Do not exceed the maximum continuous control current given in the specifications.

The Hall voltage leads may be connected directly to a readout instrument, such as a high impedance voltmeter, or can be attached to electronic circuitry for amplification or conditioning. Device signal levels will be in the range of microvolts to hundreds of millivolts.

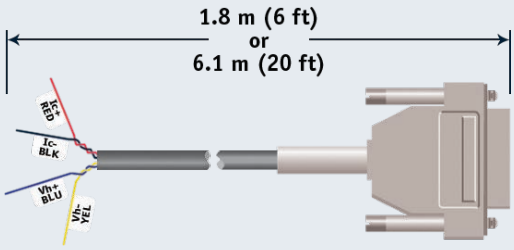
The Hall generator input is not isolated from its output. In fact, impedance levels on the order of the input resistance are all that generally exist between the two ports. To prevent erroneous current paths, which can cause large error voltages, the current supply must be isolated from the output display or the down stream electronics.

A Typical Hall Effect Measurement Scheme



Attaching Discrete Hall Generators to Lake Shore Gaussmeters

Lake Shore provides cable assemblies containing the necessary electronic memory (EEPROM) to interface a Hall generator to a gaussmeter. This allows users to assemble a Hall sensor into a difficult to access area prior to gaussmeter attachment. The figure below shows the general cable configuration. While convenient, this method provides less than optimum performance. Because of the intricacies involved with proper calibration, the user is responsible for the measurement accuracy. A probe fully calibrated by Lake Shore is always suggested. Special probe mechanical configurations are also available.



Certain Hall generator sensitivity constraints are applicable:

Sensitivities between 5.5 and 10.5 mV/kG at 100 mA control current.

Sensitivities between 0.55 and 1.05 mV/kG at 100 mA control current.

For the Model 460, 450, and 421 Gaussmeters
2 m (6 ft) and 6.1 m (20 ft) cables are available.

The cable is shipped with a disk containing the small program "Hallcal.exe," which is used to transfer the Hall generator single-point sensitivity data to the cable EEPROM through the gaussmeter serial port. This program must be installed on an IBM PC compatible computer. (A null modem cable or adapter is required).

For the Model 475 and 455 Gaussmeters
2 m (6 ft) and 6.1 m (20 ft) cables are available.

The Model 475 and Model 455 offer the convenience of front panel programming. No external computer is required. The Hall generator serial number and single-point sensitivity are directly entered using the keypad.

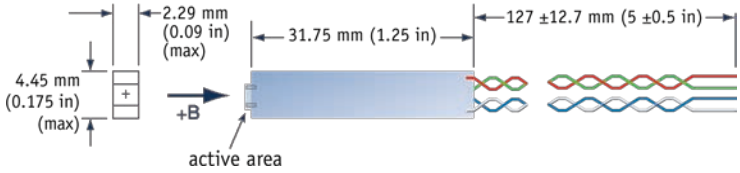
Ordering Information

Part number	Description
MCBL-6	1.8 m (6 ft) long cable for Model 460, 450, and 421
MCBL-20	6.1 m (20 ft) long cable for Model 460, 450, and 421
HMCBL-6	1.8 m (6 ft) long cable for Model 475 and 455
HMCBL-20	6.1 m (20 ft) long cable for Model 475 and 455

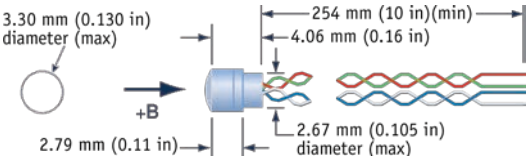
All specifications are subject to change without notice

Axial Hall Generators

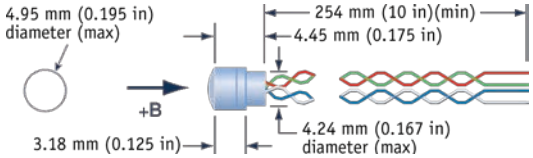
HGA-2010



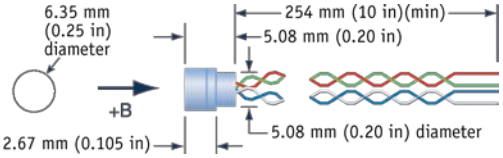
HGA-2302



HGA-2303



HGA-3010*, HGA-3030*



**The active area is symmetrical with the center line of the assembly and is located approximately 0.030 in behind the front surface of the assembly*

	HGA-2010†	HGA-2302	HGA-2303	HGA-3010	HGA-3030
Description	General purpose axial; high sensitivity	General purpose axial; 3.30 mm (0.13 in) diameter	General purpose axial; 4.95 mm (0.195 in) diameter	Instrumentation quality axial; low temperature coefficient; phenolic package	Instrumentation quality axial; phenolic package
Active area (approx)	0.127 × 0.127 mm (0.005 in × 0.005 in) square	0.51 × 1.02 mm (0.020 × 0.040 in) rectangle	0.51 × 1.02 mm (0.020 × 0.040 in) rectangle	0.76 mm (0.030 in) diameter circle	0.76 mm (0.030 in) diameter circle
Input resistance (approx)	450 Ω to 900 Ω	2 Ω	2 Ω	1 Ω	2 Ω
Output resistance (approx)	550 Ω to 1350 Ω	2 Ω	2 Ω	1 Ω	2 Ω
Nominal control current (I_{CN})	1 mA	100 mA			
Maximum continuous current (non-heat sinked, 25 °C)	10 mA	150 mA	200 mA	300 mA	
Magnetic sensitivity (I_C = nominal control current)	11 mV/kG to 28 mV/kG	5.5 mV/kG to 11.0 mV/kG	5.5 mV/kG to 11.0 mV/kG	0.55 mV/kG to 1.05 mV/kG	6.0 mV/kG to 10.0 mV/kG
Maximum linearity error (sensitivity vs. field, % rdg)	±1 (-10 kG to +10 kG) ±2 (-20 kG to +20 kG)	±1 (-10 kG to +10 kG)		±1 (-30 kG to +30 kG) ±1.5 (-100 kG to +100 kG)	±0.30 (-10 kG to +10 kG) ±1.25 (-30 kG to +30 kG)
Zero field offset voltage (I_C = nominal control current)	±2.8 mV (max)	±100 μV (max)		±50 μV (max)	±75 μV (max)
Operating temperature range	-40 °C to +100 °C				
Mean temperature coefficient of magnetic sensitivity	-0.06%/°C (max)	-0.08%/°C (max)		-0.005%/°C (max)	-0.04%/°C (max)
Mean temperature coefficient of offset (I_C = nominal control current)	±1.2 μV/°C (max)	±1 μV/°C (max)		±0.4 μV/°C (max)	±0.3 μV/°C (max)
Mean temperature coefficient of resistance	+0.15%/°C (approx)	+0.18%/°C (approx)	+0.18%/°C (approx)	+0.15%/°C (approx)	+0.18%/°C (approx)
Leads	34 AWG copper with poly-nylon insulation	36 AWG copper with poly-nylon insulation	34 AWG copper with poly-nylon insulation	34 AWG copper with poly-nylon insulation	34 AWG copper with poly-nylon insulation
Data	Single sensitivity value at I_C = 1 mA	Single sensitivity value at I_C = 100 mA	Single sensitivity value at I_C = 100 mA	Room temperature, 30 kG data supplied	

†Compatible with Lake Shore Model 410 gaussmeter only

Ordering Information

Part number	Description
HGA-2010	General purpose axial Hall generator; plastic package
HGA-2302	General purpose axial Hall sensor; phenolic shoulder
HGA-2303	General purpose axial Hall sensor; phenolic shoulder
HGA-3010	Instrumentation quality axial Hall generator; phenolic package
HGA-3030	Instrumentation quality axial Hall generator; phenolic package

Accessories available

CAL-1X-DATA	1-axis Hall generator recalibration with certificate and data

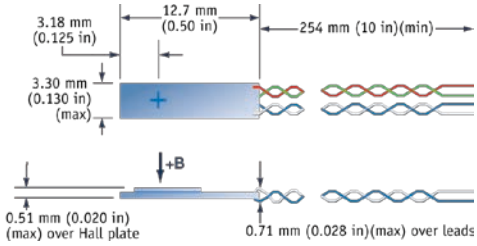
All specifications are subject to change without notice

Lead Colors:

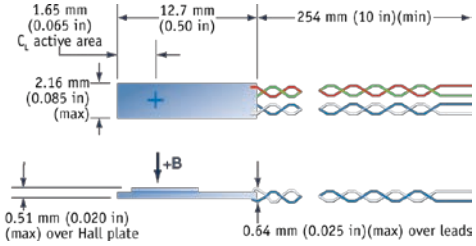
Red	$+I_C$
Green	$-I_C$
Blue	$+V_H$
Clear	$-V_H$

Transverse Hall Generators

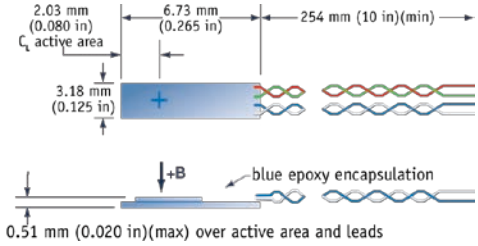
HGT-1010



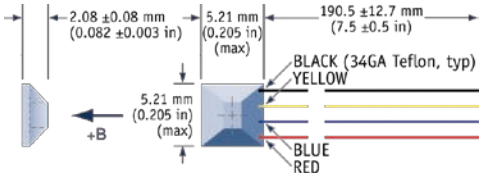
HGT-1020


1.65 mm (0.065 in)
C active area
12.7 mm (0.50 in)
254 mm (10 in)(min)
2.16 mm (0.085 in) (max)
+B
0.51 mm (0.020 in) (max) over Hall plate
0.64 mm (0.025 in)(max) over leads

HGT-1050


2.03 mm (0.080 in)
C active area
6.73 mm (0.265 in)
254 mm (10 in)(min)
3.18 mm (0.125 in)
+B
blue epoxy encapsulation
0.51 mm (0.020 in)(max) over active area and leads

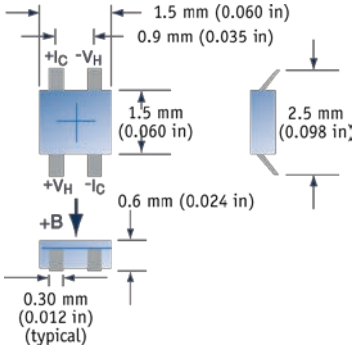
HGT-1070



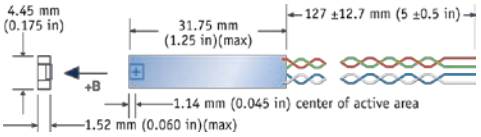
Lead Colors

Red $+I_C$
Green $-I_C$ (1070—black)
Blue $+V_H$
Clear $-V_H$ (1070—yellow)

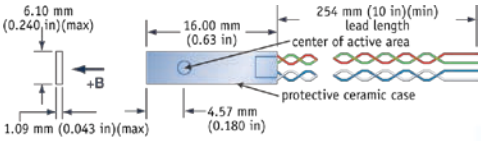
HGT-2101



HGT-2010



HGT-3010, HGT-3030



	HGT-1010	HGT-1020	HGT-1050	HGT-1070*	HGT-2010**	HGT-2101**†	HGT-3010	HGT-3030
Description	General purpose transverse		General purpose transverse; flat mount	Low field for magnetic circuit applications	General purpose transverse; high sensitivity	Low cost; high sensitivity; surface mount	Instrumentation quality transverse; low temp coefficient; ceramic package	Instrumentation quality transverse ceramic package
Active area (approx)	1.02 mm (0.040 in) diameter circle	0.76 mm (0.030 in) diameter circle	1.52 × 2.03 mm (0.06 × 0.08 in) rectangle	—	0.127 × 0.127 mm (0.005 × 0.005 in) square		1.02 mm (0.040 in) diameter circle	
Input resistance (approx)	2 Ω			4 Ω (max)	450 Ω to 900 Ω		1 Ω	2 Ω
Output resistance (approx)	2 Ω			4 Ω (max)	550 Ω to 1350 Ω	600 Ω to 2000 Ω	1 Ω	2 Ω
Nominal control current (I_{CN})	100 mA			200 mA	1 mA		100 mA	
Maximum continuous current (non-heat sinked, 25 °C)	250 mA	200 mA	250 mA	300 mA	10 mA		300 mA	
Magnetic sensitivity (I_C = nominal control current)	7.5 mV/kG to 12.5 mV/kG			8 mV at 100 Oe (min)	11 mV/kG to 28 mV/kG		0.55 mV/kG to 1.05 mV/kG	6.0 mV/kG to 10.0 mV/kG
Maximum linearity error (sensitivity versus field)	±1.0% rdg (-10 to 10 kG)		±1.0% rdg (0 to 10 kG)	—	±1% rdg (-10 to 10 kG) ±2% rdg (-20 to 20 kG)	±2.0% rdg (-10 to 10 kG)	±1% rdg (-30 to 30 kG) ±1.5% rdg (-100 to 100 kG)	±0.30% rdg (-10 to 10 kG) ±1.25% rdg (-30 to 30 kG)
Zero field offset voltage (I_C = nominal control current)	±100 μV (max)			150 μV (max)	±2.8 mV (max)		±50 μV (max)	±75 μV (max)
Operating temperature range	-40 °C to +100 °C		-65 °C to 100 °C	-40 °C to +100 °C		-55 °C to +125 °C	-40 °C to +100 °C	
Mean temperature coefficient of magnetic sensitivity	-0.08%/°C (max)			-0.15%/°C (max)	-0.06%/°C (max)		-0.005%/°C max	-0.04%/°C (max)
Mean temperature coefficient of offset (I_C = nominal control current)	±1 μV/°C (max)			±3 μV/°C (max)	±1.2 μV/°C (max)	±6 μV/°C (max)	±0.4 μV/°C (max)	±0.3 μV/°C
Mean temperature coefficient of resistance	+0.18%/°C (approx)				+0.15%/°C (approx)	+0.3%/°C (approx)	+0.15%/°C (approx)	+0.18%/°C (approx)
Leads	34 AWG copper with poly-nylon insulation	36 AWG copper with poly-nylon insulation	34 AWG copper with poly-nylon insulation	34 AWG copper with Teflon® insulation	34 AWG copper with poly-nylon insulation	NA	34 AWG copper with poly-nylon insulation	
Data	Single sensitivity value at I_C = 100 mA			Single sensitivity value at H = 100 Oe	Single sensitivity value at I_C = 1 mA	Uncalibrated	Room temperature, 30 kG data supplied	

**Cannot be used with Lake Shore gaussmeters* ***Compatible with Lake Shore Model 410 gaussmeter only*
†The Model 2101 is a replacement for the Model 2100; consult Lake Shore for comparison

Ordering Information

Part number	Description
HGT-1010	General purpose transverse Hall generator
HGT-1020	General purpose transverse Hall generator
HGT-1050	General purpose transverse Hall generator; flat mount
HGT-1070	Ferrite embedded transverse Hall generator
HGT-2010	General purpose transverse Hall generator
HGT-2101	Surface mount transverse Hall generator
HGT-3010	Instrumentation quality transverse Hall generator; ceramic package
HGT-3030	Instrumentation quality transverse Hall generator; ceramic package

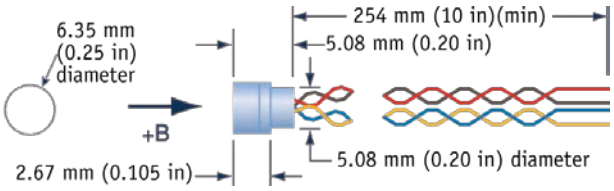
Accessories available

CAL-1X-DATA 1-axis Hall generator recalibration with certificate and data *(not available for HGT-2101)*

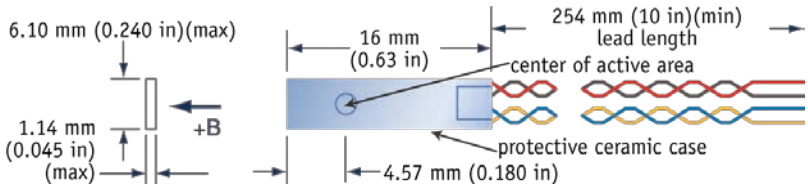
All specifications are subject to change without notice

Cryogenic Hall Generators

HGCA-3020



HGCT-3020



	HGCA-3020	HGCT-3020
Description	Cryogenic axial; phenolic package	Cryogenic transverse; ceramic package
Active area (approx)	0.76 mm (0.030 in) diameter circle	1.02 mm (0.040 in) diameter circle
Input resistance (approx)	1 Ω	
Output resistance (approx)	1 Ω	
Nominal control current (I_{CN})	100 mA	
Maximum continuous current (non-heat sinked, 25 °C)	300 mA	
Magnetic sensitivity (I_C = nominal control current)	0.55 mV/kG to 1.05 mV/kG	
Maximum linearity error (sensitivity vs field)	±1.0% rdg (-30 kG to +30 kG) ±2.0% rdg (-150 kG to +150 kG)	
Zero field offset voltage (I_C = nominal control current)	±200 μV (max)	
Operating temperature range	1.5 K to 375 K	
Mean temperature coefficient of magnetic sensitivity	*see temperature error table below*	
Mean temperature coefficient of offset (I_C = nominal control current)	±0.4 μV/K (max)	
Mean temperature coefficient of resistance	+0.6%/K (max)	
Leads	34 AWG copper with Teflon® insulation	
Data	Room temperature, 30 kG data supplied	

Temperature Error Table

The magnetic sensitivity generally increases as the temperature drops below 300 K. However, this trend reverses between 200 K and 100 K, and the sensitivity decreases at an increasing rate as the temperature cools. The sensitivity increase versus room temperature is as follows:

	Change in Magnetic Sensitivity (approximate)
Room Temp	Ref
200 K	+0.05%
100 K	–0.04%
80 K	–0.09%
20 K	–0.4%
4 K	–0.7%
1.5 K	–1.05%

Lead Colors:

Red	$+I_C$
Black	$-I_C$
Blue	$+V_H$
Yellow	$-V_H$

Ordering Information

Part number	Description
HGCA-3020	Cryogenic axial Hall generator; phenolic package
HGCT-3020	Cryogenic transverse Hall generator; ceramic package

Accessories available

CAL-1X-DATA	1-axis Hall generator recalibration with certificate and data

All specifications are subject to change without notice

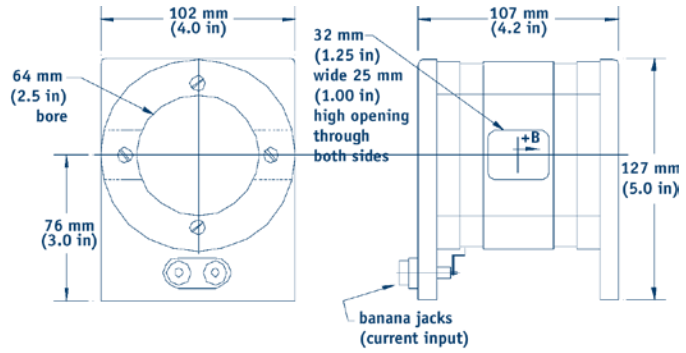
Helmholtz Coils (Field Standards)

for use with current source or power supply only

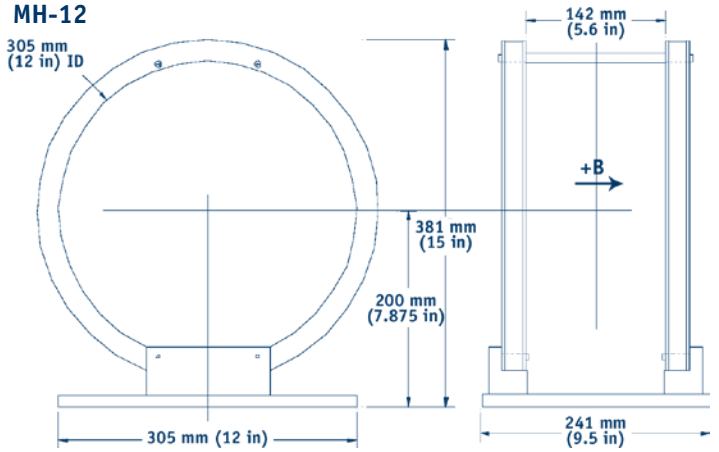
We offer four Helmholtz coils for field standards: 64 mm (2.5 in), 152 mm (6 in), and 305 mm (12 in) diameter single-axis, and the MX-2X-10 double-axis coil.

	MH-2.5	MH-6	MH-12	MH-2X-10
Field accuracy (center)	0.75%			
Inside diameter	64 mm (2.5 in)	152 mm (6 in)	305 mm (12 in)	305 mm (12 in) x-axis and 248 mm (9.75 in) y-axis
Field strength	≈30 G at 1 A	≈25 G at 1 A	≈13 G at 1 A	≈15 G at 1 A (note: coils are not exactly matched)
Field uniformity	0.5% within a cylindrical volume 19 mm (0.75 in) long, 19 mm (0.75 in) diameter, at center of coil	0.5% within a cylindrical volume 41 mm (1.6 in) long, 41 mm (1.6 in) diameter, at center of coil	0.5% within a cylindrical volume 76 mm (3.0 in) long, 76 mm (3.0 in) diameter, at center of coil	≈0.5% within a 64 mm (2.5 in) cube, at center of coil
DC coil resistance/ inductance (approx)	3 Ω/6.3 mH	10 Ω/36 mH	20 Ω/93 mH	20 Ω (x-axis), 15 Ω (y-axis)/ 128 mH (x-axis), 74 mH (y-axis)
Max continuous current	2 A (DC or RMS)			
Operating temp range	-20 °C to 40 °C (-4 °F to 104 °F)			

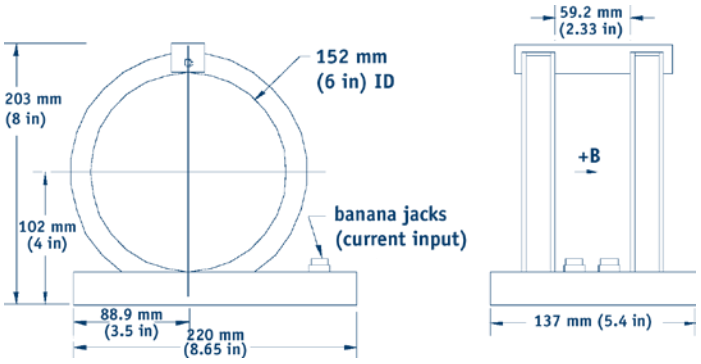
MH-2.5


102 mm (4.0 in)
107 mm (4.2 in)
64 mm (2.5 in) bore
32 mm (1.25 in) wide 25 mm (1.00 in) high opening through both sides
+B
127 mm (5.0 in)
76 mm (3.0 in)
banana jacks (current input)

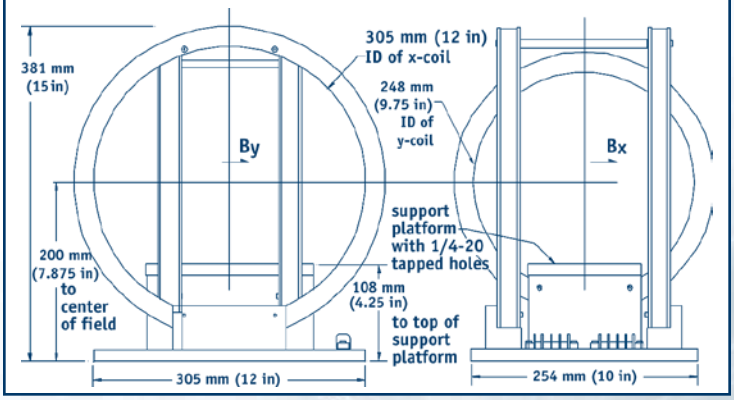
MH-12



MH-6



MH-2X-10


305 mm (12 in) ID of x-coil
381 mm (15 in)
248 mm (9.75 in) ID of y-coil
By
Bx
support platform with 1/4-20 tapped holes
200 mm (7.875 in) to center of field
108 mm (4.25 in) to top of support platform
305 mm (12 in)
254 mm (10 in)

Ordering Information

Part number	Description
MH-2.5	64 mm (2.5 in) inside diameter, maximum field approximately 60 G
MH-6	152 mm (6 in) inside diameter, maximum field approximately 50 G
MH-12	305 mm (12 in) inside diameter, maximum field approximately 26 G
MH-2X-10	305 mm (12 in) inside diameter (x-axis), 248 mm (9.75 in) inside diameter (y-axis), maximum field approximately 30 G

NOTE: The MH Series coils are for use as low field standards. They cannot be used with the Model 480 fluxmeter.

All specifications are subject to change without notice

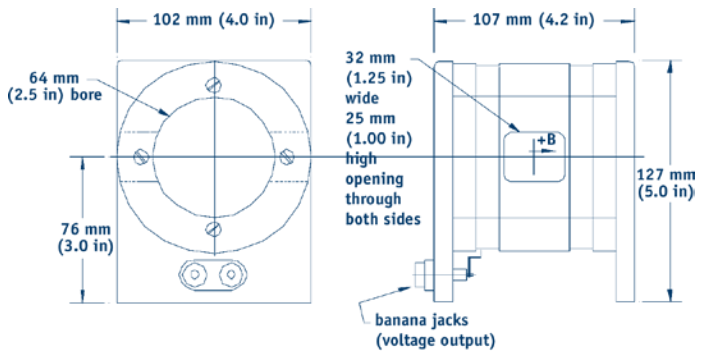
Helmholtz Coils (Magnet Moment Measurement)

for use with the Model 480 fluxmeter only

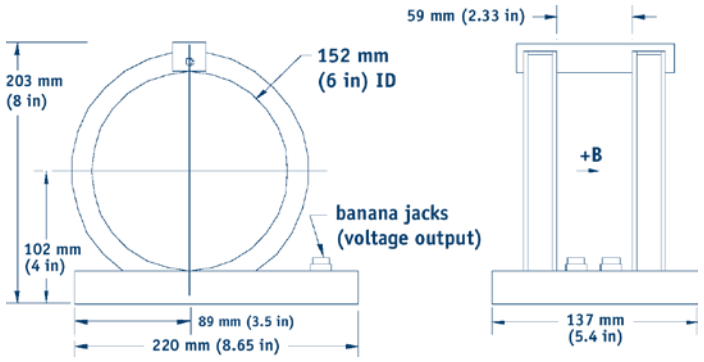
We offer three Helmholtz coils for fluxmeter moment measurements: 64 mm (2.5 in), 152 mm (6 in), and 305 mm (12 in) diameter.

	FH-2.5		FH-6		FH-12	
Calibration accuracy	0.75%					
Inside diameter	64 mm (2.5 in)		152 mm (6 in)		305 mm (12 in)	
Coil resistance (approx)	35 Ω		110 Ω		140 Ω	
Operating temperature range	0 °C to 60 °C					
Coil constant (approx)	0.013 Wb·cm/V·s		0.016 Wb·cm/V·s		0.047 Wb·cm/V·s	
Input resistance (fluxmeter)	10 kΩ	100 kΩ	10 kΩ	100 kΩ	10 kΩ	100 kΩ
Range (approx)	390 μWb·cm	3.9 mWb·cm	480 μWb·cm	4.8 mWb·cm	1.4 mWb·cm	14 mWb·cm
	39 μWb·cm	390 μWb·cm	48 μWb·cm	480 μWb·cm	140 μWb·cm	1.4 mWb·cm

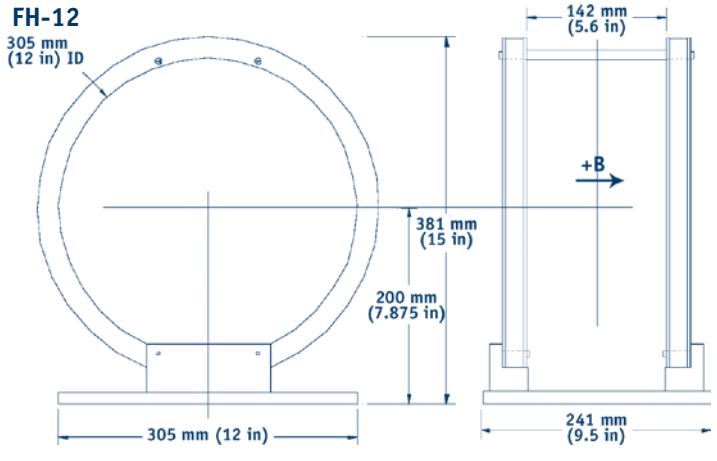
FH-2.5



FH-6



FH-12



Ordering Information

Part number	Description
FH-2.5	64 mm (2.5 in) Helmholtz coil
FH-6	152 mm (6 in) Helmholtz coil
FH-12	305 mm (12 in) Helmholtz coil

All specifications are subject to change without notice

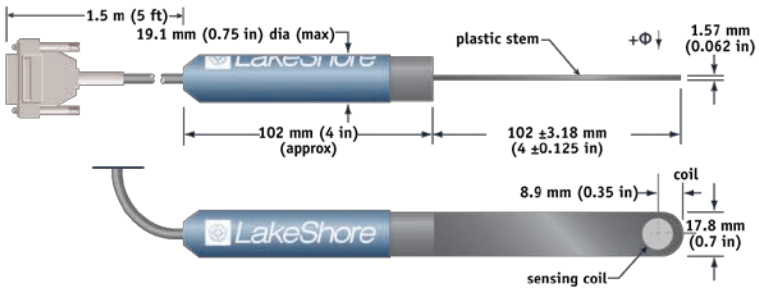
NOTE: **The FH Series coils are for use with the Lake Shore Model 480 fluxmeter only. They cannot be used with the Model 475, 455, 460, 450, or 421 gaussmeters.**

Search Coils
for use with the Model 480 fluxmeter only

Search Coils
The 100 cm² field probe is the most commonly used search coil, while the 30 cm² field probe is useful for measurements in narrow gaps or where field gradients dictate the use of a smaller coil diameter.

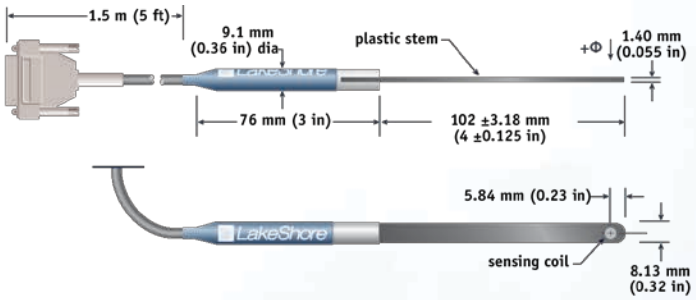
	FNT-6R04-100				FNT-5P04-30			
Calibration accuracy	0.25%				0.35%			
Area-turns (approx)	100 cm²				30 cm²			
Coil resistance (approx)	6.5 Ω				110 Ω			
Average coil diameter	10.4 mm				3.9 mm			
Operating temperature range	0 °C to 60 °C							
Input resistance (fluxmeter)	10 kΩ		100 kΩ		10 kΩ		100 kΩ	
DC ranges	Φ	B	Φ	B	Φ	B	Φ	B
	30 mV·s 3 mV·s	3 T 300 mT	300 mV·s 30 mV·s	30 T 3 T	30 mV·s 3 mV·s	10 T 1 T	300 mV·s 30 mV·s	100 T 10 T
Additional AC ranges	300 μV·s 30 μV·s 3 μV·s	30 mT 3 mT 300 μT	3 mV·s 300 μV·s 30 μV·s	300 mT 30 mT 3 mT	300 μV·s 30 μV·s 3 μV·s	100 mT 10 mT 1 mT	3 mV·s 300 μV·s 30 μV·s	1 T 100 mT 10 mT

FNT-6R04-100



NOTE: +Φ is designated as that flux passing through the coil, into the side with the Lake Shore logo on the probe handle

FNT-5P04-30



NOTE: +Φ is designated as that flux passing through the coil, into the side with the Lake Shore logo on the probe handle

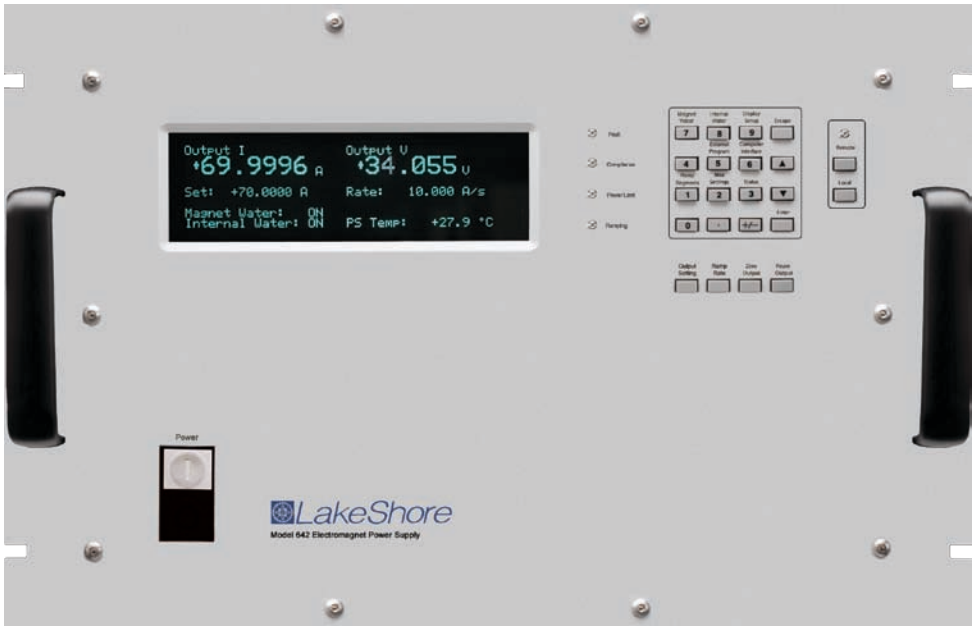
Ordering Information

Part number	Description
FNT-5P04-30	Field probe: 30 cm²
FNT-6R04-100	Field probe: 100 cm²

All specifications are subject to change without notice

Model 642 Electromagnet Power Supply

- Bipolar, linear, true 4-quadrant output
- ±70 A/±35 V, 2.5 kW
- Can be modulated to frequencies up to 0.17 Hz at ±70 A
- Low noise
- 0.1 mA of programmed current resolution
- Analog programming and IEEE-488 and RS-232C interfaces
- Built-in fault protection
- Compact design



CE *compliant to both the low voltage directive and the electromagnetic compatibility (EMC) directive, which includes the radiated emissions requirements*

Introduction

The Model 642 electromagnet power supply is a linear, bipolar current source providing true 4-quadrant output, eliminating the need for external switching or operator intervention to reverse current polarity. The Model 642 is capable of supplying ±70 A/±35 V to a nominal 0.5 Ω, 0.5 H load, and the output can be modulated from an external source to frequencies up to 0.17 Hz at ±70 A. Internally programmed output provides 20-bit resolution, while externally programmed output provides unlimited resolution.

The compact, low-noise design of the Model 642 makes it the ideal supply for use in laboratory settings. When combined with a Lake Shore EM4 4-inch electromagnet and Model 475 DSP gaussmeter, the Model 642 provides a versatile field control system ideal for a wide range of user defined applications. These include but are not limited to magneto-optical, magnetic hysteresis and susceptibility, and Hall effect measurements, as well as in-line annealing.

Output architecture

The Model 642 output architecture relies on low-noise linear input and output stages. The linear circuitry of the Model 642 permits operation with less electrical noise than switch-mode electromagnet power supplies. The clean field background allows greater resolution and finer detail in results drawn from data taken during high sensitivity experiments. One key benefit of this architecture is CE compliance to the electromagnetic compatibility (EMC) directive, including the radiated emissions requirement.

The true 4-quadrant output capability of the Model 642 is ideal for sweeping through both positive and negative fields. Tightly integrated analog control of the 4-quadrant output provides smooth current change with very low overshoot. This eliminates the need for external switching or operator intervention to reverse the polarity, significantly simplifying system design. The transition through zero current is smooth and continuous, allowing the user to readily control the magnetic field as polarity changes. This is achieved without reversal contactors or relays, which would produce unintended field spikes and other discontinuities. As a result, field hysteresis and other biases are avoided in the experimental data.

Output programming
The Model 642 output current is programmed internally via the keypad or the computer interface, externally by analog programming input, or by the sum of the external and internal settings. For internal programming, the Model 642 incorporates a proprietary 20-bit digital-to-analog converter (DAC) that is monotonic over the entire output range and provides resolution of 0.1 mA. External programming provides unlimited resolution.

The Model 642 generates extremely smooth and continuous ramps with virtually no overshoot. The digitally generated constant current ramp rate is variable between 0.1 mA/s and 99.999 A/s. To ensure smooth ramp rate, the power supply updates the high-resolution DAC 23.7 times per second. A low-pass filter on the output DAC smooths the transitions at step changes during ramping.

Output reading
The Model 642 provides high-resolution output readings. The output current reading reflects the actual current in the magnet, and has a resolution of 0.1 mA. The output voltage reading reports the voltage at the output terminals with a resolution of 100 µV. All output readings can be prominently displayed on the front panel and read over the computer interface.

Protection
The Model 642 provides built-in protection against short circuit, open circuit, line loss, low line voltage, high line voltage, output over voltage, output over current, over temperature, and abrupt change of the external programming input. In the event of water flow failure, flow sensors provide feedback to the Model 642 and output current is set to 0 A. Internal heat sink, cold plate, and transformer temperatures are also monitored. Warnings are displayed before temperature limits are exceeded and current is set to 0 A. If temperatures continue to increase over safety limits, the Model 642 turns off.

A proprietary circuit limits the power dissipated in the water-cooled cold plate if low resistance and high line conditions exist. The Model 642 protects itself if operated into resistances outside of nominal limits. By limiting current output, the power supply will safely operate into a shorted load, and it operates safely into high resistance loads by limiting voltage output. The Model 642 is also protected against power loss under full operation and nominal magnet load. Both low and high power line conditions are reported on the front panel display.

Interfaces
The Model 642 includes both parallel IEEE-488 and serial RS-232C computer interfaces that provide access to operating data, stored parameters, and remote control of all front panel operating functions. The Model 642 also provides two analog monitors for output current and voltage. Each monitor is a buffered, differential, analog voltage representation of the signal being monitored. The current monitor has a sensitivity of 7 V/70 A output, while the voltage monitor has a sensitivity of 3.5 V/35 V output.

Display and keypad
The Model 642 incorporates a large 8-line by 40-character vacuum fluorescent display. Output current and output voltage readings are displayed simultaneously. Five front panel LEDs provide quick verification of instrument status, including ramping, compliance, fault, power limit, and computer interface mode. Error conditions are indicated on the main display along with an audible beeper. Extended error descriptions are available under the status key.

The keypad is arranged logically to separate the different functions of the power supply. The most common functions of the power supply are accessed using a single button press. The keypad can be locked in order to secure either all changes or just the instrument setup parameters, allowing the supply output to be changed.

Model 642 Specifications

Output
Type: Bipolar, 4-quadrant, DC current source
Current generation: Fully linear regulation with digital setting and analog control
Current range: ±70 A
Compliance voltage (DC): ±35 V nominal
Power: 2450 W nominal
Load resistance range: 0.4 Ω to 0.6 Ω
Load inductance range: 0 to 1 H
Nominal load: 0.5 Ω, 0.5 H
Current ripple: 5 mA RMS (0.007%) at 70 A into nominal load
Current ripple frequency: Dominated by the line frequency and its harmonics
Temperature coefficient: ±15 ppm of full scale/°C
Line regulation: ±60 ppm of full scale/10% line change
Stability (1 h): 1 mA/h (after warm-up)
Stability (24 h): 5 mA/24 h (typical, dominated by temp. coefficient and line regulation)
Isolation: Differential output is optically isolated from chassis to prevent ground loops
Slew rate: 50 A/s into nominal load, 650 A/s minimum into a resistive load
Compliance voltage (AC): ±43 V nominal
Settling time: <1 s for 10% step to within 1 mA of output into nominal load
Modulation response: ≤0.17 Hz at ±70 A sine wave into nominal load, <0.02% THD; ≤10 Hz at ±10 A sine wave into nominal load, <0.10% THD
Attenuation: -0.5 dB at 10 Hz
Protection: Short circuit, line loss, low line voltage, high line voltage, output over voltage, output over current, and over temperature
Connector: Two lugs with 6.4 mm (0.25 in) holes for M6 or 0.25 in bolts

Output Programming
Internal current setting
Resolution: 0.1 mA (20-bit)
Settling time: 600 ms for 1% step to within 1 mA (of internal setting)
Accuracy: ±10 mA ±0.05% of setting
Operation: Keypad, computer interface
Protection: Programmable current setting limit

Internal current ramp
Ramp rate: 0.1 mA/s to 99.999 A/s (compliance limited)
Update rate: 23.7 increments/s
Ramp segments: 5
Operation: Keypad, computer interface
Protection: Programmable ramp rate limit

External current programming
Sensitivity: 10 V/70 A
Resolution: Analog
Accuracy: ±10 mA ±1% of setting
Input resistance: 20 kΩ
Operation: Voltage program through rear panel, can be summed with internal current setting
Limits: Internally clamped at ±10.1 V and bandwidth limited at 40 Hz to protect output
Connector: Shared 15-pin D-sub

Readings
Output current
Resolution: 0.1 mA
Accuracy: ±5 mA ±0.05% of reading
Update rate: 2.5 rdg/s display, 10 rdg/s interface

Output voltage (at supply terminals)
Resolution: 1 mV
Accuracy: ±5 mV ±0.05% of rdg
Update rate: 2.5 rdg/s display, 5 rdg/s interface

Front panel
Display type: 8-line by 40-character graphic vacuum fluorescent module
Display readings: Output current, output voltage, and internal water temperature
Display settings: Output current and ramp rate
Display annunciators: Status and errors
LED annunciators: Fault, Compliance, Power Limit, Ramping, Remote
Audible annunciator: Errors and faults
Keypad type: 26 full-travel keys
Keypad functions: Direct access to common operations, menu-driven setup
Power: White flush ON and black extended OFF push buttons

Interface
IEEE-488.2 interface
Features: SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT0, C0, E1
Reading rate: To 10 rdg/s
Software support: National Instruments LabVIEW™ driver (consult Lake Shore for availability)

Serial interface
Electrical format: RS-232C
Baud rates: 9600, 19200, 38400, 57600
Reading rate: To 10 rdg/s
Connector: 9-pin D-sub (DTE)

Output current monitor
Sensitivity: 7 V/70 A
Accuracy: ±1% of full scale
Noise: 1 mV RMS
Source impedance: 20 Ω
Connector: Shared 15-pin D-sub

Output voltage monitor
Sensitivity: 3.5 V/35 V
Accuracy: 1% of full scale
Noise: 1 mV RMS
Source impedance: 20 Ω
Connector: Shared 15-pin D-sub

Power supply cooling water
Remote enable input: TTL low or contact closure to enable output; jumper required if unused
Valve power output: 24 VAC at 1 A maximum, automatic or manual control
Connector: Shared 4-pin detachable terminal block
Flow switch and water valve optional

Magnet cooling water
Remote enable input: TTL low or contact closure to enable output; jumper required if unused
Valve power output: 24 VAC at 1 A maximum, automatic or manual control
Connector: Shared 4-pin detachable terminal block
Flow or temperature switch and water valve not included

Auxiliary
Emergency stop: Requires 1 A, 24 VAC normally closed contact closure to enable power-up; jumper required if unused
Fault output: Relay with normally open or normally closed contact, 30 VDC at 1 A
Remote enable input: TTL low or contact closure to enable output; jumper required if unused
Connector: Shared 8-pin detachable terminal block
Emergency stop and inhibit switches not included

General

Line power
Power: 5500 VA max
Voltage and current: 204/208 VAC ±10%, 13 A/phase; 220/230 VAC ±10%, 12 A/phase; 380 VAC ±10%, 7 A/phase; 400/415 VAC ±10%, 6.5 A/phase
Protection: 3-phase thermal relay with adjustable current setting; two class cc ¼ A fuses; over-voltage lockout circuit
Frequency: 50 or 60 Hz
Configuration: 3-phase delta
Connector: 4-pin terminal block
Line voltage must be specified at time of order but is field reconfigurable; cable from power supply to facility power not included

Cooling water
Flow rate: 5.7 L (1.5 gal) per min minimum
Pressure range: 34 kPa (5 PSI) to 552 kPa (80 PSI)
Pressure drop: 10 kPa (1.5 PSI) at 5.7 L (1.5 gal) per min minimum for power supply only
Temperature: 15 °C to 30 °C (non condensing)
Connection: Two 10 mm (0.375 in) hose barbs
CAUTION: Internal condensation can cause damage to the power supply

Enclosure type: 7 U high, 19 in rack mount with integral rack mount ears, 25 mm (1 in) air space required on each side for ventilation
Size: 483 mm W × 310 mm H × 572 mm D (19 in × 12.2 in × 22.5 in) with handles removed
Weight: 74 kg (163 lb)
Shipping size: 635 mm W × 559 mm H × 737 mm D (25 in × 22 in × 29 in)
Shipping weight: 80 kg (175 lb)
Ambient temperature: 15 °C to 35 °C at rated accuracy, 5 °C to 40 °C at reduced accuracy
Humidity: non condensing
Warm-up: 30 min at output current setting
Approvals: CE mark–low voltage compliance to EN61010-3, EMC compliance to EN55022-1
Calibration schedule: 1 year

Ordering Information

Part Number	Description
642-204	Model 642 ±70 A ±35 V, 2.5 kW, 204/208 VAC
642-225	Model 642 ±70 A ±35 V, 2.5 kW, 220/230 VAC
642-380	Model 642 ±70 A ±35 V, 2.5 kW, 380 VAC
642-408	Model 642 ±70 A ±35 V, 2.5 kW, 400/415 VAC

Accessories Included

6031	Two front handles
6032	Two rear handles
6051	Terminal block, 4-pin
6052	Terminal block, 8-pin
6252	15-pin D-sub mating connector, analog I/O
—	Hose clamps
—	Power cable strain relief (power cable not included)
—	Calibration certificate
MAN-642	Model 642 user manual

Accessories Available

6201	1 m (3.3 ft) long IEEE-488 (GPIB) computer interface cable assembly
6261	3 m (10 ft) magnet cable kit, AWG 4
6262	6 m (20 ft) magnet cable kit, AWG 4
CAL-642-CERT	Instrument recalibration with certificate
CAL-642-DATA	Instrument recalibration with certificate and data
6041	Water flow switch
6042	Water valve

All specifications are subject to change without notice

Bipolar Magnet Power Supplies

Models 665 and 668

- Linear, bipolar, water-cooled power supply
- 100 ppm class current stability
- Low ripple noise (from 5 mV)
- 5 kW and 8.8 kW
- CE compliant
- Local and remote programming and monitoring
- LEDs indicating power supply status
- Power output disable upon fault detection
- Thermally protected
- Output connectors at cabinet rear, protected by removable cover
- Steel cabinet with wheels and leveling feet

Model 665 and Model 668 Bipolar Magnet Power Supply (665: 50 V, 100 A, 5 kW, 668: 65 V, 135 A, 8.8 kW)

The 660 series are true linear, bipolar DC power supplies using a fixed diode rectifier to convert AC to DC, and a pass transistor stage to regulate the output to the power supply. They act as a DC current source and can be operated manually from the front panel or remotely via a ±10 V input. The user can also set current and voltage limits. The bipolar operation of these power supplies provides a smooth transition through zero, eliminating the need for current reversal contactors or relays.

Linear magnet power supplies have several advantages over switch mode power supplies, including smooth field generation that is nearly free from offending electromagnetic signatures. The clean field background allows greater resolution and finer detail in results drawn from data taken during high sensitivity experiments.

Bipolar architecture furthers the idea of clean field generation. The 660 series power supplies maintain tight control over the entire output range, including zero output. This is achieved without reversal contactors or relays, which produce unintended field spikes and other discontinuities. As a result, field hysteresis and other biases are avoided in experimental data.

The front panel displays the current and voltage outputs with 0.1 A and 0.1 V resolution. The current can be controlled via 100% (full-scale) and 1% (fine adjust) ten-turn indexed potentiometers. The voltage limit is also set via potentiometer. The front panel has connectors for external monitoring of both of these signals. There are 4 green LEDs to indicate when the power supply is on, the status of interlocks, and when the unit is ready for operation. Displaying faults for internal and external failures, overheating, overload, and overpower are 9 red LEDs. High speed fault detection for transistors helps avoid cascade output failures. The front panel also includes switches for standby, output start, polarity, and local/remote mode.

The 660 Series can be controlled by the user via any ±10 V input or by a Lake Shore Model 475 gaussmeter. The combination of these power supplies with an electromagnet and Model 475 gaussmeter form a versatile electromagnet field control system. This system is ideally suited for integration into customer-designed magnetic test platforms for applications including magneto-optical studies, magnetic hysteresis studies, in-line annealing, Hall effect studies, susceptibility measurements, spin magnetic resonance demonstrations, and biological studies. Refer to page 60 for more information.

Specifications

Output current and voltage:
Model 665: ±100 A, ±50 V (5 kW)
Model 668: ±135 A, ±65 V (8.8 kW)

Ramp rate:
Up to 10 A/s

Load:
Resistive electromagnet or any equivalent resistive load. Supplies are compensated for typical electromagnets — highly inductive loads may require tuning in the field.

Nominal load:
Model 665: 0.5 Ω
Model 668: 0.5 Ω

Minimum load (consult Lake Shore for other magnet load requirements)**:**
Model 665: 0.25 Ω
Model 668: 0.35 Ω

Output current stability:
±(0.01% of reading + 0.01% of full scale range)
under conditions of constant line voltage, load, and temperature

Current noise:
±(0.001% of reading + 0.001% of full scale range) peak to peak,
between 0.01 Hz and 1 Hz

Voltage ripple:
5 mV RMS + 0.01% of full scale range

Output settings:
Current setpoint, current limit, and voltage limit

Output programming:
Local via two 10-turn potentiometers (100%, 1%);
remote via ±10 V programming input (BR2 connector)

Output displays:
Current and voltage outputs displayed with digital resolution of ≥0.1 A

Output voltage monitor:
±10 V full scale (BR2 connector)

Output current monitor:
±10 V full scale (BR2 connector)

Current output connections:
9.5 mm threaded studs with nuts

On/off control:
Front panel separate on, off, and reset push buttons; remote on/off capable

Power supply fault detection circuitry:
- Transistor fault detect
- Slew rate limit protection
- Internal condensation protection
- Overheat protection
- Overpower protection
- Overload protection
- External interlocks

Input power:
Model 665: (7.6 kVA max)
21 A/phase with 208/220 VAC between phases
11 A/phase with 380/400 VAC between phases
Model 668: (15.5 kVA max)
39 A/phase with 208 VAC between phases
19 A/phase with 400 VAC between phases
Custom voltage configurations are available

50–60 Hz; 3-phase plus ground (4-wire)

Line voltage must be specified at time of order.
Cable from power supply to facility power not included.

Cooling water requirements (minimum at 0.5 Ω nominal load):
Model 665: flow rate: 8 L/min (2.1 gal/min)
pressure drop: 0.12 MPa (17 psi)
Model 668: flow rate: 8 L/min (2.1 gal/min)
pressure drop: 0.14 MPa (20 psi)

Cooling water connections:
Model 665 and 668: ¼-inch NPT female thread; ¼-inch NPT male to 10 mm (~3/8 in) hose barb included

Operating environment:
Ambient temperature: +10 °C to +30 °C (50 °F to 86 °F)
Humidity: 55% ±10% (non-condensing)
Cooling water: +15 °C to +25 °C (59 °F to 77 °F)
CAUTION: Internal condensation can cause damage to the power supply.

Mechanical outline:
Freestanding rack cabinet with locking wheels and 4 lifting eye bolts

Size and weight:
Model 665: 1.35 m high × 0.7 m deep × 0.6 m wide
(53.1 in × 27.6 in × 23.6 in); 250 kg (550 lb)
Model 668: 1.35 m high × 0.7 m deep × 0.6 m wide
(53.1 in × 27.6 in × 23.6 in); 354 kg (780 lb)

Shipping size and weight:
Model 665: 1.52 m × 0.84 m × 0.76 m (60 in × 33 in × 30 in); 295 kg (650 lb)
Model 668: 1.78 m × 0.91 m × 0.76 m (70 in × 36 in × 30 in); 400 kg (880 lb)

Ordering Information

Part number	Description
Model 665-208	±100 A, ±50 V, 5.0 kW, 208 VAC
Model 665-220	±100 A, ±50 V, 5.0 kW, 220 VAC
Model 665-380	±100 A, ±50 V, 5.0 kW, 380 VAC
Model 665-400	±100 A, ±50 V, 5.0 kW, 400 VAC
Model 668-208	±135 A, ±65 V, 8.8 kW, 208 VAC
Model 668-220	±135 A, ±65 V, 8.8 kW, 220 VAC
Model 668-380	±135 A, ±65 V, 8.8 kW, 380 VAC
Model 668-400	±135 A, ±65 V, 8.8 kW, 400 VAC

Consult Lake Shore for other available voltages
All specifications are subject to change without notice

Electromagnets EM4-HVA, EM7-HV

- Continuously adjustable poles allow rapid air gap changes to suit individual experiments, assuring magnet versatility
- Exceptional field intensities achieved with cylindrical or tapered pole caps
- Water-cooled coils provide excellent field stability and uniformity
- Removable pole caps facilitate variable pole face configurations and easy pole cap exchange
- Accurate pole alignment by precise construction of the air gap adjustment mechanism
- The EM7 yoke is oriented at a 45° angle and the EM4 yoke at a 40° angle for optimum air gap accessibility
- Compact size of the EM4 permits convenient bench-top mounting
- Optional optical access pole caps available

Model EM4-HVA Electromagnet with optional stand

Model EM7-HV Electromagnet

The Lake Shore EM4 and EM7 series electromagnets (EM) produce variable magnetic fields with a variety of air gap and pole cap configurations. The EM series are ideally suited for integration into customer-designed magnetic test platforms for applications including magneto-optical studies, magnetic hysteresis studies, in-line annealing, Hall effect studies, susceptibility measurements, spin magnetic resonance demonstrations, and biological studies.

The HV series feature continuously adjustable poles, allowing rapid air gap changes to suit individual experiments, and threaded or bolt-on mounting that provides easy pole cap exchange. The EM series incorporate water-cooled coils and precision yokes made of magnetically soft, ultra-pure steel, assuring precise pole cap alignment as well as excellent field homogeneity and stability. The EM7 yoke is oriented at a 45° angle and the EM4 yoke at a 40° angle for optimum air gap accessibility. The EM4 series are also compact in size and have steel eyebolts, permitting convenient bench-top mounting to optical tables.

The EM series coupled with a Lake Shore magnet power supply (MPS) form a versatile laboratory electromagnet characterization system. This system, with true bipolar MPS power output, provides rapid uniform magnetic field ramping and field reversal to avoid discontinuities that occur during zero crossover when using unipolar power supplies.

Larger magnets are also available from Lake Shore.

Specifications

Typical Field Uniformity (EM4 Magnets)

Magnet configuration		Uniformity	1% cylindrical volume	
Pole cap mm (in)	Air gap mm (in)	over 1 cm^3	Diameter mm (in)	Length mm (in)
102 (4.0)	51 (2.0)	±0.15%	18 (0.7)	51 (2.0)
102 (4.0)	25 (1.0)	±0.05%	64 (2.5)	25 (1.0)
76 (3.0)	25 (1.0)	±0.06%	46 (1.8)	25 (1.0)
51 (2.0)	25 (1.0)	±0.35%	18 (0.7)	25 (1.0)
51 (2.0)	13 (0.5)	±0.16%	36 (1.4)	13 (0.5)

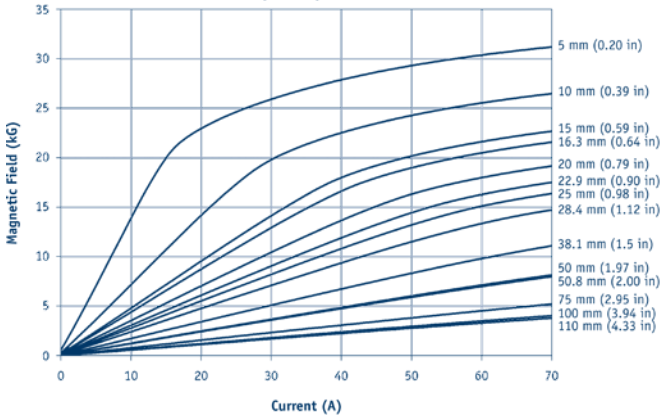
The third column gives uniformity over one cubic centimeter volume centered in the magnet gap. The last two columns give the cylindrical volume within which the magnetic field deviates by less than 1% from the central field. The cylindrical volume is coaxial with the magnet poles and centered in the gap.

Typical Field Uniformity (EM7 Magnet)

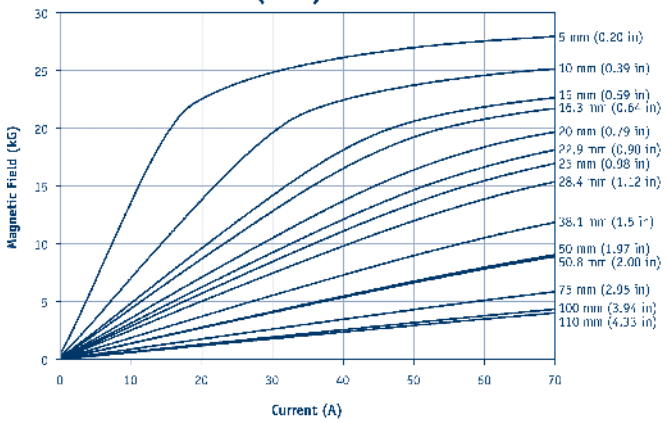
Magnet configuration		Uniformity	1% cylindrical volume	
Pole cap mm (in)	Air gap mm (in)	over 1 cm^3	Diameter mm (in)	Length mm (in)
51 (2.0)	16 (0.6)	±0.11%	28 (1.1)	16 (0.6)
51 (2.0)	25 (1.0)	±0.33%	10 (0.4)	25 (1.0)
102 (4.0)	16 (0.6)	±0.03%	74 (2.9)	16 (0.6)
102 (4.0)	25 (1.0)	±0.03%	66 (2.6)	25 (1.0)
102 (4.0)	38 (1.5)	±0.05%	48 (1.9)	38 (1.5)
102 (4.0)	51 (2.0)	±0.08%	23 (0.9)	51 (2.0)

	EM4-HVA	EM7-HV
Air gap	Up to 109 mm (4.3 in) continuously variable	Up to 178 mm (7 in) continuously variable
Coil resistance, nominal	0.25 Ω per coil (0.5 Ω total wired in series)	1.0 Ω per coil (0.5 Ω total wired in parallel)
Standard pole cap diameter	51 mm (2 in)	76 mm (3 in)
Optional pole cap diameter	25 mm, 76 mm, 102 mm (1 in, 3 in, 4 in)	51 mm, 102 mm, 152 mm (2 in, 4 in, 6 in)
Cooling water	Tap water or closed cooling system	
Water flow rate	7.6 L/min (2 gal/min)	11.4 L/min (3 gal/min)
Pressure drop	200 kPa (30 psi)	220 kPa (32 psi)
Water chiller cooling capacity	2.5 kW (8,530 BTU/h)	5.0 kW (17,060 BTU/h)
Water inlet temperature	15 °C to 25 °C (59 °F to 77 °F)	
Coil over temperature limit	70 °C (158 °F)	
Coil spacing, nominal	121 mm (4.75 in)	178 mm (7 in)
Coil size-width, nominal	121 mm (4.75 in)	132 mm (5.2 in)
Coil size-diameter, nominal	311 mm (12.25 in)	445 mm (17.5 in)
Current (maximum continuous operating)	±70 A per coil	±50 A per coil
Voltage, nominal	±35 V	±50 V
Continuous input power, nominal	2.5 kVA	5 kVA
Lake Shore power supply (suggested)	Model 642	Model 665
	Size	
Height	0.39 m at 40° angle (15.25 in) without stand	0.94 m (37 in)
Width	0.84 m (33.25 in)	1.02 m (40 in)
Depth	0.51 m (20 in)	0.66 m (26 in)
Weight	201.9 kg (445 lb)	635 kg (1400 lb)
Shipping weight	215.5 kg (475 lb)	660 kg (1500 lb)
Shipping dimensions	0.97 m × 0.58 m × 0.56 m (38 in × 23 in × 22 in)	0.86 m × 1.22 m × 1.19 m (34 in × 48 in × 47 in)

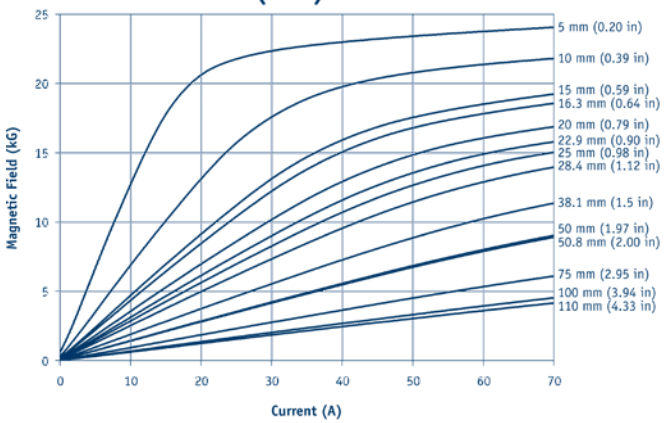
EM4-HVA 25 mm (1 in) Pole Face Field Plot



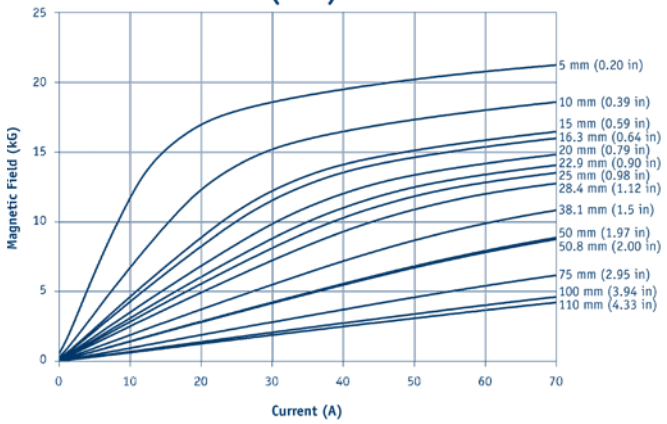
EM4-HVA 51 mm (2 in) Pole Face Field Plot



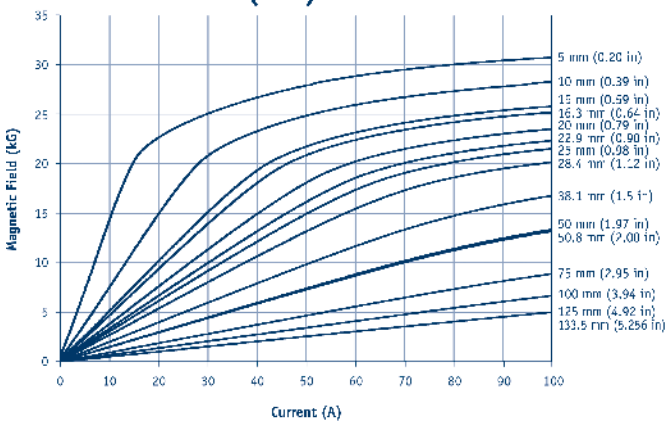
EM4-HVA 76 mm (3 in) Pole Face Field Plot



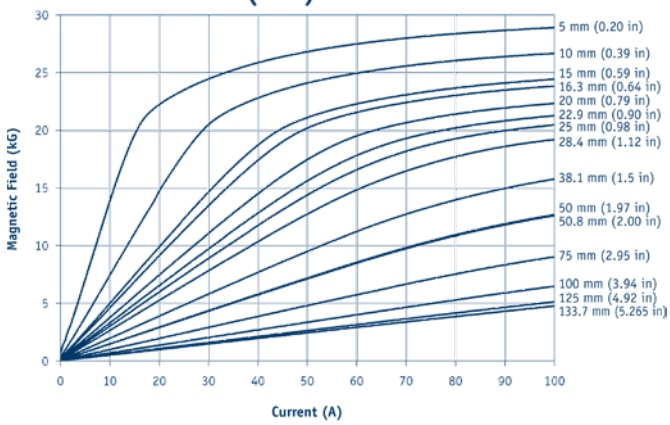
EM4-HVA 102 mm (4 in) Pole Face Field Plot



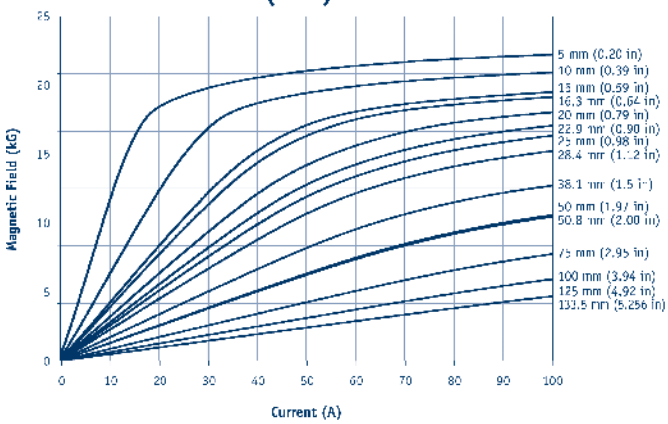
EM7-HV 51 mm (2 in) Pole Face Field Plot



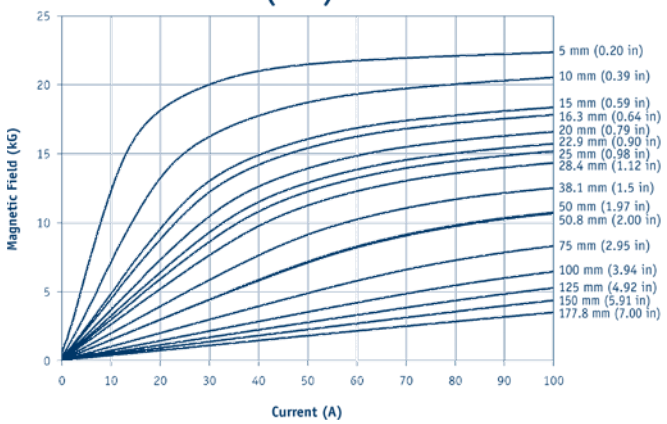
EM7-HV 76 mm (3 in) Pole Face Field Plot



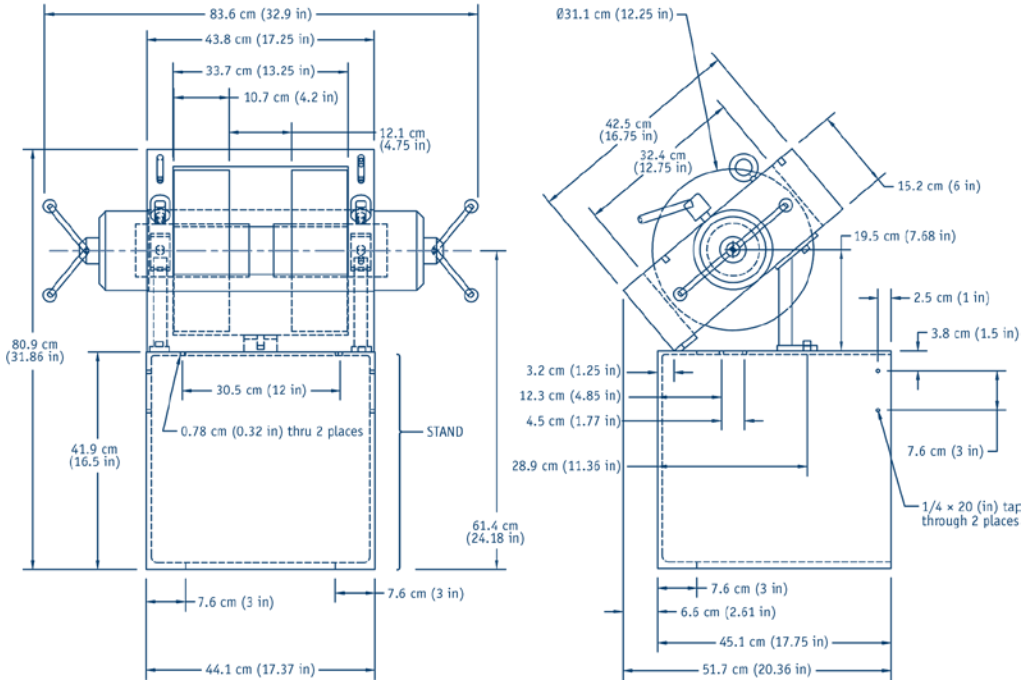
EM7-HV 102 mm (4 in) Pole Face Field Plot



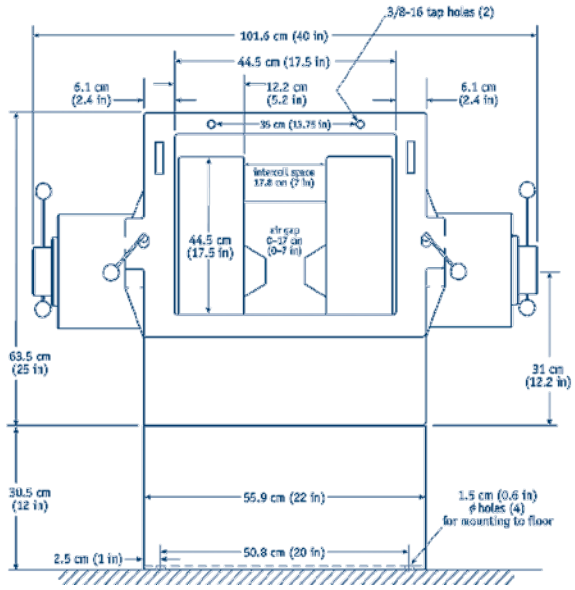
EM7-HV 152 mm (6 in) Pole Face Field Plot

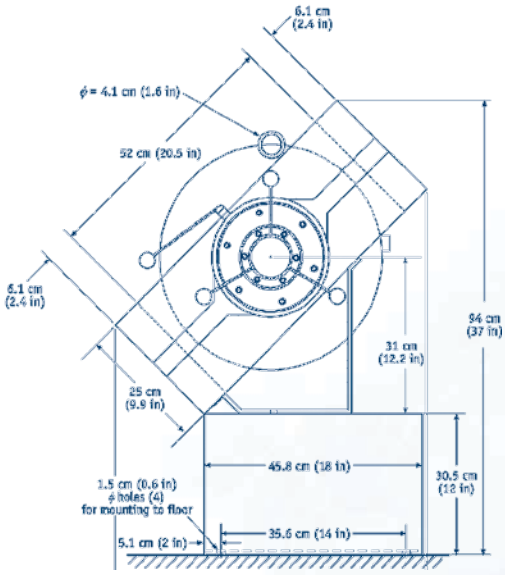


EM4-HVA (without stand) and EM4-HVA-S (with stand)



EM7-HV


3/8-16 tap holes (2)
101.6 cm (40 in)
44.5 cm (17.5 in)
6.1 cm (2.4 in)
12.2 cm (5.2 in)
6.1 cm (2.4 in)
35 cm (13.75 in)
Intercoil space 17.8 cm (7 in)
44.5 cm (17.5 in)
airgap 0–17 cm (0–7 in)
63.5 cm (25 in)
31 cm (12.2 in)
30.5 cm (12 in)
55.9 cm (22 in)
1.5 cm (0.6 in) ϕ holes (4) for mounting to floor
2.5 cm (1 in)
50.8 cm (20 in)


6.1 cm (2.4 in)
ϕ = 4.1 cm (1.6 in)
52 cm (20.5 in)
6.1 cm (2.4 in)
94 cm (37 in)
31 cm (12.2 in)
25 cm (9.9 in)
45.8 cm (18 in)
30.5 cm (12 in)
1.5 cm (0.6 in) ϕ holes (4) for mounting to floor
5.1 cm (2 in)
35.6 cm (14 in)

EM4-HSTAND-3—Aluminum 3-level support structure for EM4-HVA magnets

- Bottom access to the center of the magnet
- Compact 0.86 m (34 in) high, 3-level aluminum structure supports the magnet and provides a flexible structure for mounting of additional hardware
- Leveling feet
- Raises the center of the magnet 0.61 m (2 ft) above the ground to provide a comfortable height for sample exchange
- Plate below and above the magnet provided to support test structures or instrumentation

Weight: 54.4 kg (120 lb, not including magnet), **Dimensions:** 0.58 m W × 0.51 m D × 0.86 m H (23 in W × 20 in D × 34 in H), **Shipping weight:** 269.9 kg (595 lb, with EM4-HVA magnet), **Shipping dimensions:** 0.91 m W × 0.61 m D × 1.09 m H (36 in × 24 in × 43 in)

EM4-STAND-2—2-level support structure for all EM4-HVA magnets

- Compact 0.53 m (21 in) high, 2-level aluminum support structure supports the magnet and provides a flexible mounting structure
- Leveling feet

Weight: 35.4 kg (78 lb, not including magnet), **Dimensions:** 0.58 m W × 0.51 m D × 0.53 m H (23 in W × 20 in D × 21 in H), **Shipping weight:** 252 kg (555 lb, with EM4-HVA magnet), **Shipping dimensions:** 0.91 m W × 0.61 m D × 0.76 m H (36 in W × 24 in D × 30 in H)

Ordering Information

102 mm (4 in) Electromagnets

EM4-HVA	H yoke, variable gap (up to 102 mm [4 in]) without stand
EM4-HVA-O	H yoke, variable gap (up to 102 mm [4 in]) with optical access
EM4-HVA-S	H yoke, variable gap (up to 102 mm [4 in]) with stand
EM4-HVA-S-O	H yoke, variable gap (up to 102 mm [4 in]) with optical access & stand

Accessories included
1 set of pole caps (EM4-2PB, 51 mm [2 in] pole cap standard — different size can be specified at time of order); corresponding pair of lead screws; flow switch; 3 m (10 ft) #4 AWG cables

Accessories available

EM4-1PB	Pole cap, 1 pair, 102 mm (4 in) dia. tapered to 25 mm (1 in) face
EM4-2PB	Pole cap, 1 pair, 102 mm (4 in) dia. tapered to 51 mm (2 in) face
EM4-3PB	Pole cap, 1 pair, 102 mm (4 in) dia. tapered to 76 mm (3 in) face
EM4-4PB	Pole cap, 1 pair, 102 mm (4 in) dia. with 102 mm (4 in) face
EM4-1PB-O-1-2	Pole cap, 1 pair, 102 mm (4 in) tapered to 25 mm (1 in) face, 3.2 mm (1/8 in) dia. bore for optical access through one pole
EM4-1PB-O-2-2	Pole cap, 1 pair, 102 mm (4 in) tapered to 25 mm (1 in) face, 3.2 mm (1/8 in) dia. bore for optical access through both poles
EM4-1PB-O-1-4	Pole cap, 1 pair, 102 mm (4 in) tapered to 25 mm (1 in) face, 6.4 mm (1/4 in) dia. bore for optical access through one pole
EM4-1PB-O-2-4	Pole cap, 1 pair, 102 mm (4 in) tapered to 25 mm (1 in) face, 6.4 mm (1/4 in) dia. bore for optical access through both poles
EM4-2PB-O-1-2	Pole cap, 1 pair, 102 mm (4 in) tapered to 51 mm (2 in) face, 3.2 mm (1/8 in) dia. bore for optical access through one pole
EM4-2PB-O-2-2	Pole cap, 1 pair, 102 mm (4 in) tapered to 51 mm (2 in) face, 3.2 mm (1/8 in) dia. bore for optical access through both poles
EM4-2PB-O-1-4	Pole cap, 1 pair, 102 mm (4 in) tapered to 51 mm (2 in) face, 6.4 mm (1/4 in) dia. bore for optical access through one pole
EM4-2PB-O-2-4	Pole cap, 1 pair, 102 mm (4 in) tapered to 51 mm (2 in) face, 6.4 mm (1/4 in) dia. bore for optical access through both poles
EM4-3PB-O-1-2	Pole cap, 1 pair, 102 mm (4 in) tapered to 76 mm (3 in) face, 3.2 mm (1/8 in) dia. bore for optical access through one pole
EM4-3PB-O-2-2	Pole cap, 1 pair, 102 mm (4 in) tapered to 76 mm (3 in) face, 3.2 mm (1/8 in) dia. bore for optical access through both poles
EM4-3PB-O-1-4	Pole cap, 1 pair, 102 mm (4 in) tapered to 76 mm (3 in) face, 6.4 mm (1/4 in) dia. bore for optical access through one pole
EM4-3PB-O-2-4	Pole cap, 1 pair, 102 mm (4 in) tapered to 76 mm (3 in) face, 6.4 mm (1/4 in) dia. bore for optical access through both poles
EM4-4PB-O-1-2	Pole cap, 1 pair, 102 mm (4 in) dia. with 102 mm (4 in) face, 3.2 mm (1/8 in) dia. bore for optical access through one pole
EM4-4PB-O-2-2	Pole cap, 1 pair, 102 mm (4 in) dia. with 102 mm (4 in) face, 3.2 mm (1/8 in) dia. bore for optical access through both poles
EM4-4PB-O-1-4	Pole cap, 1 pair, 102 mm (4 in) dia. with 102 mm (4 in) face, 6.4 mm (1/4 in) dia. bore for optical access through one pole
EM4-4PB-O-2-4	Pole cap, 1 pair, 102 mm (4 in) dia. with 102 mm (4 in) face, 6.4 mm (1/4 in) dia. bore for optical access through both poles
EM4-CABLE	Cable from magnet to supply (#4 AWG, 3 m [10 ft])
EM4-FLOW	Flow switch, replacement
EM4-HSTAND-3	3-level support structure for EM4-HVA with leveling feet
EM4-STAND-2	2-level support structure for EM4-HVA with leveling feet

All specifications are subject to change without notice

178 mm (7 in) Electromagnets

EM7-HV	H yoke, variable gap (up to 178 mm [7 in]) with stand
EM7-HV-O	H yoke, variable gap (up to 178 mm [7 in]) with optical access and stand

Accessories included
1 set of pole caps, corresponding pair of lead screws, flow switch, 3 m (10 ft) #4 AWG cables

Accessories available

EM7-2P-FECO	Pole cap, 1 pair, 178 mm (7 in) dia. tapered to 51 mm (2 in) face, FeCo
EM7-2P	Pole cap, 1 pair, 178 mm (7 in) dia. tapered to 51 mm (2 in) face
EM7-3P	Pole cap, 1 pair, 178 mm (7 in) dia. tapered to 76 mm (3 in) face
EM7-4P	Pole cap, 1 pair, 178 mm (7 in) dia. tapered to 102 mm (4 in) face
EM7-6P	Pole cap, 1 pair, 178 mm (7 in) dia. tapered to 152 mm (6 in) face
EM7-3P-O-1-2	Pole cap, 1 pair, 178 mm (7 in) tapered to 76 mm (3 in) face, 3.2 mm (1/8 in) dia. bore for optical access through one pole
EM7-3P-O-2-2	Pole cap, 1 pair, 178 mm (7 in) tapered to 76 mm (3 in) face, 3.2 mm (1/8 in) dia. bore for optical access through both poles
EM7-3P-O-1-4	Pole cap, 1 pair, 178 mm (7 in) tapered to 76 mm (3 in) face, 6.4 mm (1/4 in) dia. bore for optical access through one pole
EM7-3P-O-2-4	Pole cap, 1 pair, 178 mm (7 in) tapered to 76 mm (3 in) face, 6.4 mm (1/4 in) dia. bore for optical access through both poles
EM7-6P-O-1-2	Pole cap, 1 pair, 178 mm (7 in) tapered to 152 mm (6 in) face, 3.2 mm (1/8 in) dia. bore for optical access through one pole
EM7-6P-O-2-2	Pole cap, 1 pair, 178 mm (7 in) tapered to 152 mm (6 in) face, 3.2 mm (1/8 in) dia. bore for optical access through both poles
EM7-6P-O-1-4	Pole cap, 1 pair, 178 mm (7 in) tapered to 152 mm (6 in) face, 6.4 mm (1/4 in) dia. bore for optical access through one pole
EM7-6P-O-2-4	Pole cap, 1 pair, 178 mm (7 in) tapered to 152 mm (6 in) face, 6.4 mm (1/4 in) dia. bore for optical access through both poles
EM7-CABLE	Cable from magnet to supply (#4 AWG, 3 m [10 ft])
EM7-FLOW	Flow switch, replacement

Consult Lake Shore for FeCo and other pole cap materials

Additional Requirements for EM4 and EM7 Electromagnets:

1. Water supply (see flow rate in specifications table) or recirculating water chiller
2. Crane or lifting equipment capable of lifting or moving the weight of magnet (see specifications)
3. Magnet power supply
4. Area that can support the magnet weight

- CFC-free refrigeration system
- User-adjustable low and high temperature safety with audible alarm
- A fully hermetic compressor provides trouble-free, long life performance
- Specifically designed for 24-hour, continuous duty circulation
- Compact design minimizes use of limited floor space

Recirculating Chillers

Lake Shore offers the NesLab® M-75 (Lake Shore Model RC-EM4) and M-150 (Lake Shore Model RC-EM7) recirculating chillers in order to provide a complete laboratory solution. The NesLab chillers feature a CFC-free refrigeration system.

The refrigeration system utilizes a hermetically sealed compressor and hot gas bypass system of temperature control. This system eliminates on/off cycling and premature wear of the compressor. Strong pumps provide continuous flow even through cooling lines with small IDs.

Specifications

	RC-EM4-200230-60-CE	RC-EM4-200-50-CE	RC-EM4-230-50-CE	RC-EM7-200230-60-CE	RC-EM7-200-50-CE	RC-EM7-400-50-CE
Electromagnet	EM4	EM4	EM4	EM7	EM7	EM7
NesLab model number	M-75	M-75	M-75	M-150*	M-150*	M-150*
Capacity	2410 W	2180 W	2180 W	5045 W	4540 W	4540 W
Power requirements	200 to 230 V, 60 Hz, 9 A	200 V, 50 Hz, 9 A	220 V to 230 V, 50 Hz, 9 A	200 to 230 V, 60 Hz, 15 A	200 V, 50 Hz, 15 A	400 V/3-phase, 50 Hz, 8 A
Volume	3.7 gpm at 35 psi	3.1 gpm at 35 psi	3.1 gpm at 35 psi	6 gpm at 40 psi	3.2 gpm at 30 psi	3.2 gpm at 30 psi
	General					
Pump	PD-2	PD-2	PD-2	CP-55	PD-2	PD-2
Temperature range	5 °C to 35 °C	5 °C to 35 °C	5 °C to 35 °C	5 °C to 35 °C	5 °C to 35 °C	5 °C to 35 °C
Temperature stability	±0.15 °C	±0.15 °C	±0.15 °C	±0.15 °C	±0.15 °C	±0.15 °C
Reservoir volume (gal/L)	0.5/1.8	0.5/1.8	0.5/1.8	0.5/1.8	0.5/1.8	0.5/1.8
Case dimensions (in) (mm)	26.2 × 16.3 × 24.0 664 × 413 × 610	26.2 × 16.3 × 24.0 664 × 413 × 610	26.2 × 16.3 × 24.0 664 × 413 × 610	30.4 × 21.3 × 29.3 772 × 541 × 743	30.4 × 21.3 × 29.3 772 × 541 × 743	30.4 × 21.3 × 29.3 772 × 541 × 743
Shipping weight	91 kg (200 lb)	91 kg (200 lb)	91 kg (200 lb)	130 kg (287 lb)	130 kg (287 lb)	130 kg (287 lb)

Performance specifications will be affected by changes in temperature, ambient, or coolant.
** M-150 can be used with the EM7 magnet, but do not operate the magnet above the rated wattage.*

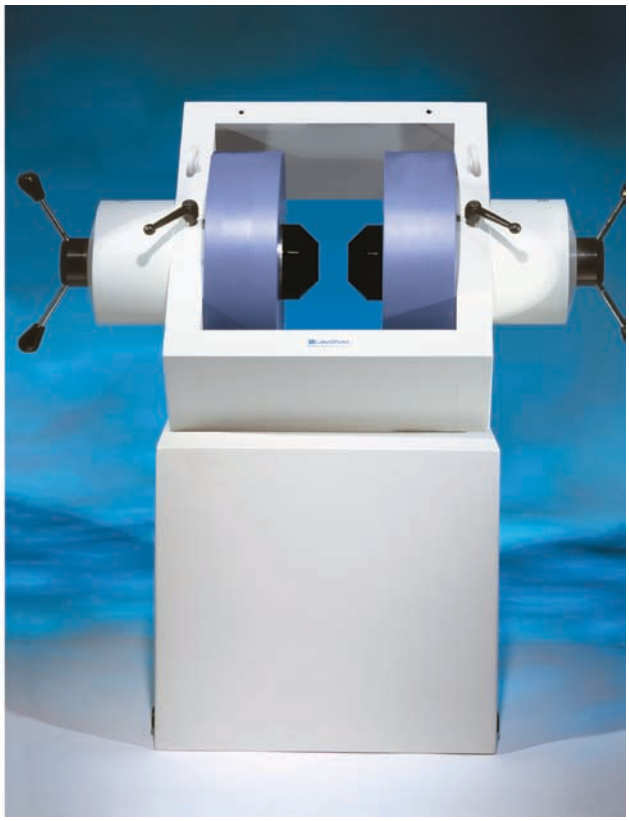
Ordering Information

Part number	Description
RC-EM4-200230-60-CE	2410 W (60 Hz) recirculating chiller
RC-EM4-200-50-CE	2180 W (50 Hz) recirculating chiller
RC-EM4-230-50-CE	2180 W (50 Hz) recirculating chiller
RC-EM7-200230-60-CE	5045 W (60 Hz) recirculating chiller
RC-EM7-200-50-CE	4540 W (50 Hz) recirculating chiller
RC-EM7-400-50-CE	4540 W (50 Hz) recirculating chiller

All specifications are subject to change without notice

The chillers we offer are rated at 65% duty cycle. This is appropriate for many common magnet testing applications such as hysteresis loops and other measurement applications where the operating cycle is spent at low to medium current, with only limited excursions to high fields. It may be appropriate to choose a larger chiller for higher duty cycle needs, when large magnetic fields must be maintained continuously. Please consult Lake Shore for an appropriate chiller for these applications.

Field Controlled Electromagnet Platforms



Product Description

The electromagnet field control platform (FCP) integrates hardware and firmware components to form a variable magnetic field platform that can be utilized independently or as the foundation for a user-designed magnetic measurement system.

The FCPs include a Lake Shore electromagnet, a bipolar magnet power supply, a DSP gaussmeter with integrated field control firmware, and a gaussmeter Hall probe and holder.

Lake Shore FCPs can be configured to accommodate specific user requirements based on magnetic field strength, field uniformity, sample size, and custom measurement applications. The platforms are ideally suited for integration into user-designed magnetic test systems for applications including magneto-optical studies, in-line annealing, Hall effect studies, susceptibility measurements, spin magnetic resonance demonstrations, B-H curves, and precision sensor calibration.

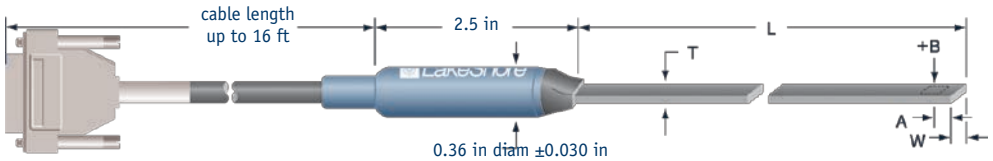
System Features

The FCP electromagnets feature continuously adjustable air gaps, allowing rapid air gap changes to suit individual experiments. They have water-cooled coils and precision yokes made of magnetically soft, ultra-pure steel, assuring precise pole cap alignment as well as excellent field homogeneity and stability.
The H-yoke configurations are oriented at a 45° angle for optimum air gap accessibility. The electromagnets also incorporate compact size with steel eyebolts, permitting convenient bench-top mounting to optical tables.

The FCP magnet power supplies provide stable current regulation and true, bipolar power output. The bipolar output allows rapid uniform magnetic field ramping and field reversal, avoiding discontinuities that occur during zero crossover when using unipolar power supplies. The bipolar output also eliminates the need for current reversal contactors or relays. The magnet power supplies are CE compliant and include features such as automatic power output disable upon failure detection, operation as a current or voltage source, and operation in either manual or remote mode.

Unlike other commercial solutions, the Lake Shore FCP system incorporates closed-loop field control (also called feedback control) capability directly into the Model 475 DSP gaussmeter, eliminating the need for a separate computer with redundant software control. The Model 475 includes the electronics and firmware to perform closed-loop, digital PI field control of the electromagnet and magnet power supply.

Gaussmeter Hall Probe



Control Features
The Model 475 attempts to keep the magnetic field density at exactly the user-entered control setpoint, expressed in gauss, tesla, oersted, or ampere/meter. To do this, the Model 475 uses feedback from the gaussmeter Hall probe to calculate and actively adjust the control (analog) output. In order to maximize control stability, the Model 475 updates the analog output every 33 ms. The result is an internal PI controller providing peak-to-peak field stability of 0.5 G*.

When the setpoint ramp is enabled, the instrument will start ramping from the current field reading, rather than the current setpoint, based on the user settable P and I settings. In addition, the 475 can be configured to ramp the control setpoint from the present field reading to a new value by using a smooth linear transition in field rather than the step response PI control.

Open-loop field control is also possible by using the Model 475 analog output in manual output, meaning feedback is ignored and the analog output stays at the manual user setting. This method makes the magnet power supply operate in constant current mode.

The Model 475 also incorporates user-settable control slope limits and analog output voltage limits. These software limits assure that the magnet power supply is not damaged if the field control system is improperly tuned or begins to oscillate.

**Measured at 0 G and 1000 G*

Gaussmeter Display
The Model 475 has a 2-line by 20-character vacuum fluorescent display. During normal operation, the display is used to report the current field value and field control setpoint. When setting instrument field control parameters, the display provides prompts for turning the control on/off, entering the control setpoint, entering the control P and I values, entering a ramp rate, and entering the control slope limit. When field control is not active, the display can be configured to show features such as maximum and minimum DC field values, RMS field value, frequency, or probe temperature.

Keypad
The instrument has a 22-position keypad with individual keys assigned to frequently used features. Menus are reserved for less frequently used setup operations. The keypad can be locked out to prevent unintended changes of instrument setup.

Computer Interface
Two computer interfaces are included with the Model 475, serial RS-232C and parallel IEEE-488. Both allow setup of all instrument parameters and read-back of measured values. The maximum reading rate over the interface is nominally 30 readings per second during field control. LabVIEW™ driver for the Model 475 is provided. Application software is not included with the FCP.

Following are examples of the various display configurations and setup screens:

The display configured to turn the field control On/Off

The display configured to enter the field control setpoint

The display configured to enter the field control 'P' value

The display configured to enter the field control 'I' value

The display configured to enter the field control ramp rate

The display configured to set the field control slope limit

The display configured to show the field control setpoint and current field value, when field control is active

Specifications

The features and specifications of Lake Shore field control platforms are consistent with their individual components and are summarized below. Detailed component specifications are included in their individual sections. Typical system performance illustrates how the components behave as a system. Field stability values were measured on a FC-EM7 system. Results will vary with magnet size, magnet gap, and system setup.

Typical system performance	**FC-EM4**	**FC-EM7**	**FC-EM10**
Field stability (peak-to-peak)	—	0.5 G at 0 G and 1 kG	—
Control type	Closed loop PI		
Control output resolution	0.001% of full scale output		
Control output update period	33 ms		
Electromagnet	**EM4-HVA**	**EM7-HV**	**EM10-HV**
See page 56 for field plots and detailed specifications			
Frame, gap	H frame, variable gap		
Nominal coil (Ω)	0.5 Ω	1.0 Ω	0.25 Ω
Coil connection	Series	Parallel	Series
Pole size	Customer specified		
Air gap	Up to 102 mm (4 in), continuously variable	Up to 178 mm (7 in), continuously variable	Up to 160 mm (6.3 in), continuously variable
Field strength	See page 56		Consult Lake Shore
Power supply	**642**	**665**	**668**
See page 48 for detailed specifications			
Output	Linear, bipolar		
Current output	±35 A per coil	±50 A per coil	±67.5 A per coil
Voltage	±35 V nominal	±50 V nominal	±65 V nominal
Power output	2.5 kW	5 kW	8.8 kW
AC line input	200/208, 220/230, 380, 400/415 VAC, 3-phase (3 wire plus ground)	208, 220, 380, 400 VAC, 3-phase (3 wire plus ground)	208 and 400 VAC, 3-phase (3 wire plus ground)
Gaussmeter	**475**		
See page 3 for detailed specifications			
Resolution	5 3/4 digit (1 part out of ±350,000)		
Ranges	8 ranges from 35 mG to 350 kG full scale		
Basic DC accuracy	±0.05%		
Frequency ranges	DC, 1 Hz to 1 kHz, and 50 Hz to 20 kHz		
Update rate	Display: 5 readings per s; IEEE-488: 30 rdg per s		
Hall probe	**HMMT-6J02-VF**	**HMMT-6J04-VF**	**HMMT-6J08-VF**
See page 31 for detailed specifications			
Length	5.1 ±3.2 mm (2 ±0.125 in)	10.2 ±3.2 mm (4 ±0.125 in)	20.3 ±3.2 mm (8 ±0.125 in)
Size/weight (H × D × W)			
Electromagnet	0.41 × 0.41 × 0.81 m (16 × 16 × 32 in); 202 kg (445 lb)	0.94 × 0.66 × 1.02 m (37 × 26 × 40 in); 614 kg (1350 lb)	0.87 × 0.64 × 0.92 m (34 × 25 × 36 in); 1800 kg (3970 lb)
Power supply	0.31 × 0.57 × 0.48 m (12 × 23 × 19 in); 74 kg (163 lb)	1.35 × 0.70 × 0.60 m (53 × 28 × 24 in); 250 kg (550 lb)	1.35 × 0.70 × 0.60 m (53 × 28 × 24 in); 354 kg (780 lb)
Gaussmeter/Hall probe	89 × 318 × 216 mm (3.5 × 12.5 × 8.5 in); 3 kg (6.6 lb)		

Ordering Information

Customer specifies single-phase voltage, 3-phase voltage, and pole cap diameter

Part number	**Description**
FC-EM4-HVA	Field controlled platform with EM4-HVA-S electromagnet
FC-EM7	Field controlled platform with EM7-HV electromagnet
FC-EM10	Field controlled platform with EM10-HV electromagnet

All specifications are subject to change without notice

Units for Magnetic Measurement

	Symbol	Gaussian & cgs emu[a]	Conversion Factor, C[b]	SI & rationalized mks[c]
Magnetic flux density, magnetic induction	B	gauss (G)[d]	10^{-4}	tesla (T), Wb/m^2
Magnetic flux	Φ	maxwell (Mx), $G \cdot cm^2$	10^{-8}	weber (Wb), volt second (V·s)
Magnetic potential difference, magnetomotive force	U, F	gilbert (Gb)	$10/4\pi$	ampere (A)
Magnetic field strength, magnetizing force	H	oersted (Oe),[e] Gb/cm	$10^3/4\pi$	A/m[f]
(Volume) magnetization[g]	M	emu/cm^3[h]	10^3	A/m
(Volume) magnetization	$4\pi M$	G	$10^3/4\pi$	A/m
Magnetic polarization, intensity of magnetization	J, I	emu/cm^3	$4\pi \times 10^{-4}$	T, Wb/m^2[i]
(Mass) magnetization	σ, M	emu/g	1 $4\pi \times 10^{-7}$	$A \cdot m^2/kg$ Wb·m/kg
Magnetic moment	m	emu, erg/G	10^{-3}	$A \cdot m^2$, joule per tesla (J/T)
Magnetic dipole moment	j	emu, erg/G	$4\pi \times 10^{-10}$	$Wb \cdot m$[j]
(Volume) susceptibility	χ, κ	dimensionless, emu/cm^3	4π $(4\pi)^2 \times 10^{-7}$	dimensionless henry per meter (H/m), Wb/(A·m)
(Mass) susceptibility	χ_ρ, κ_ρ	cm^3/g, emu/g	$4\pi \times 10^{-3}$ $(4\pi)^2 \times 10^{-10}$	m^3/kg $H \cdot m^2/kg$
(Molar) susceptibility	χ_{mol}, κ_{mol}	cm^3/mol, emu/mol	$4\pi \times 10^{-6}$ $(4\pi)^2 \times 10^{-13}$	m^3/mol $H \cdot m^2/mol$
Permeability	μ	dimensionless	$4\pi \times 10^{-7}$	H/m, Wb/(A·m)
Relative permeability[j]	μ_r	not defined	—	dimensionless
(Volume) energy density, energy product[k]	W	erg/cm^3	10^{-1}	J/m^3
Demagnetization factor	D, N	dimensionless	$1/4\pi$	dimensionless

a. Gaussian units and cgs emu are the same for magnetic properties. The defining relation is $B = H + 4\pi M$.
b. Multiply a number in Gaussian units by C to convert it to SI (e.g., $1\ G \times 10^{-4}\ T/G = 10^{-4}\ T$).
c. SI (Système International d'Unités) has been adopted by the National Bureau of Standards. Where two conversion factors are given, the upper one is recognized under, or consistent with, SI and is based on the definition $B = \mu_0(H + M)$, where $\mu_0 = 4\pi \times 10^{-7}\ H/m$. The lower one is not recognized under SI and is based on the definition $B = \mu_0 H + J$, where the symbol I is often used in place of J.
d. 1 gauss = 10^5 gamma (γ).
e. Both oersted and gauss are expressed as $cm^{-1/2} \cdot g^{-1/2} \cdot s^{-1}$ in terms of base units.
f. A/m was often expressed as "ampere-turn per meter" when used for magnetic field strength.
g. Magnetic moment per unit volume
h. The designation "emu" is not a unit
i. Recognized under SI, even though based on the definition $B = \mu_0 H + J$. See footnote c.
j. $\mu_r = \mu/\mu_0 = 1 + \chi$, all in SI. μ_r is equal to Gaussian μ.
k. $B \cdot H$ and $\mu_0 M \cdot H$ have SI units J/m^3; $M \cdot H$ and $B \cdot H/4\pi$ have Gaussian units erg/cm^3.

R. B. Goldfarb and F. R. Fickett, U.S. Department of Commerce, National Bureau of Standards, Boulder, Colorado 80303, March 1985
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Established in 1968, Lake Shore Cryotronics, Inc. is an international leader in developing innovative measurement and control solutions. Founded by Dr. John M. Swartz, a former professor of electrical engineering at the Ohio State University, and his brother David, Lake Shore produces equipment for the measurement of cryogenic temperatures, magnetic fields, and the characterization of the physical properties of materials in temperature and magnetic environments.